MONTHLY WEATHER REVIEW

Editor, EDGAR W. WOOLARD

VOL. 67, No. 9
W. B. No. 1277

SEPTEMBER 1939

CLOSED NOVEMBER 3, 1939
ISSUED DECEMBER 22, 1939

ON THE ORIGIN AND DISTRIBUTION OF THUNDERSTORM ELECTRICITY

By W. J. HUMPHREYS

[Weather Bureau, Washington, D. C., Sept. 1939]

Experiment shows that when an uncharged drop of approximately pure water, such as rain water, is broken up by a jet of air, the spray particles so produced are negatively charged and the remaining larger portion of the drop positively charged. We also know from experiment that water drops cannot fall through still air of normal density at a greater velocity than about 26 feet per second, nor fall at all through, but rather rise with, air that has a greater-than-this velocity of ascent, since drops large enough to acquire a higher velocity, if solid, are so agitated by the swiftly passing air that they break into smaller drops that are then carried up. We further know, by inference from the occurrence of large hailstones, and directly from the experience of aviators, that within thunderstorm clouds there commonly are currents of air with such velocity of ascent that rain cannot fall through them, and within which all especially large drops, formed by coalescence or otherwise, are promptly ruptured and their parts dispersed—the smaller carried off from the larger.

These facts constitute the logically coherent basis of C. G. Simpson's well-known rupture theory of the origin of thunderstorm electricity, or electrification of the cumulo-nimbus cloud whose abrupt discharge is lightning. Naturally it was inferred that of the electricity obtained in this way the negative portion, being on or associated with, the smaller droplets, must be chiefly at or near the top of the cloud, and the positive, being on the larger drops, near its base. Numerous observations, however, have shown that in general, but not always, the distribution of the electricity is just the reverse of this, that is, the upper portion of the cloud is, on the whole, positively charged and the lower portion negatively charged. This observed distribution of the electricity is so definitely opposite to that which has seemed all but inevitable on the rupture theory that many have felt compelled to reject that theory entirely, even when they knew of none other that to them was more acceptable.

But is the inference that on the rupture theory the upper portion of the cloud must be negative and the lower positive correct? Evidently the latent heat of condensation of the condensing vapor keeps the air within the rising cloud slightly warmer and therefore lighter than the outer air, level for level, otherwise there would be no ascent of the air within this cloud—nothing of the local chimney effect it displays. Clearly, too, the velocity of ascent of each small portion of the rising air must increase until the weight of the liquid water entrained by it and the friction between it and the adjacent air are together equal to its buoyancy. The mean level at which this condition occurs, or mean level of maximum velocity of ascent of the rising air within a thunderstorm cloud appears, according to the experience of aviators, to be well above the halfway point between its base and its top. Furthermore, since this velocity commonly is so great that raindrops cannot fall through the air at its level, it follows that the greatest concentration of large drops, and therefore the seat of the most active electric separation must be at a still higher level—the level at which drops can just maintain their position against the ascending air. This level, as previously explained, seems commonly to be in the upper portion of the cloud; and if that is its normal location then most of the positive charge usually is well above the midheight of the cloud in which it is produced.

The negative electricity presumably is first carried to, or near to, the top of the cumulus and then from there pulled down along, or near to, the cloud wall by the well-known descending air that commonly flows down the sides of high cumulus clouds, incident to cooling of the containing air by evaporation at the cloud surface. A portion of this descending negative electricity may be caught up by the ascending air and partially neutralize any falling positive drops, another portion largely captured by the finer cloud droplets near the base of the cloud, and the rest, together with the second portion also, and all the positive charges, either neutralized within the cloud, as is the first portion, carried down on the rain, or violently ejected in the form of discharges. At any rate the known movements of the air in and about an active thunderstorm cloud may not only produce abundant electric separation, or electrification, through rupture of the larger (maximum size) raindrops but also so distribute the charges thus produced that more positive electricity will be above the midlevel of the cloud in which it was generated than below that level. If so, then the most serious objection that has been made to the Simpson rupture theory of the electrification of the cumulo-nimbus, or thunderstorm cloud, is not an objection at all, but a confirmation.

189871—39——1

ON WEATHER CHANGES FROM DAY TO DAY

By HENRYK ARCTOWSKI

[Washington, D. C., Sept. 1939]

During the years 1898 and 1899, while making observations on board the *Belgica*, I frequently noticed an intimate relation between the successions of cloud sheets and the waves of pressure registered by the barograph.

There, in the Antarctic, in approximately 70° latitude, the mean duration of waves of at least 5 mm. amplitude was 126 hours, or 5.25 days. The pressure waves observed about 10 years later, in McMurdo Sound and Framheim, 8° or 9° farther south, were longer, since the figures given by Simpson are 6.33 and 6.79 days. Going northward, on the contrary, they become shorter: 3.79 days on the South Orkneys, in 61°; and 2.87 days on Kerguelen Island in 49° S. latitude. Thus, twice as many waves occur during the year, for a difference of 30° latitude, in the Southern Hemisphere.

These facts justify the question: Do the Antarctic pressure waves split in two, or do the figures for latitude 49° correspond to intercrossings of waves of different origin?

In lower latitudes the ups and downs of the barometer are greatly reduced in amplitude, and the well-pronounced diurnal variation excludes the use of barograms for the counting of waves.

Taking the 8 a. m. observations of Lorenço Marques, 25°58′ S. latitude, all waves of at least 2.5 mm. amplitude noted during 1910–19 gave a mean duration of 6.6 days. To obtain a figure for Batavia (6°11′ S.) comparable with that for 79° S., ups and downs of not less than 0.5 mm. had to be counted; the mean for the 10 years considered is 7.5 days. In Greenland and Iceland, taking 5 mm. as the least amplitude, the means of the years 1910–19 are 6.9 days for Upernivik, 6.5 for Godthab, and 6.5 for Vestmannö, figures similar to those for the Antarctic.

Are the equatorial waves, of small amplitude, only an attenuation of those observed in polar regions? Maps are necessary to answer this question.

For another reason, also, day-to-day world maps of isallobars should be drawn, and continued, if possible, year after year.

The monthly values of the wave lengths observed in Warsaw, for the years 1869 to 1903, have been published by Merecki.[1] Overlapping means of these data give a most interesting diagram (fig. 1) showing a variation broken by discontinuities.[2]

The highest and the lowest durations are 6.7 and 4.8 days for the means of 12 consecutive months. We must suppose, therefore, world variations of the duration or length of the waves, or displacements of the centers of most frequent intercrossings of waves of different origin.

The researches by Ekholm on maps of isallobars are well known.[3] Connected areas of increase and decrease of pressure on the map show the extent of a wave. Ekholm has given no name to the pressure waves as seen on isallobaric maps; I have proposed to apply the name *anoterons* to the areas of positive pressure differences observed from day to day at a given hour, and *katoterons* to those of pressure decrease.

The pressure wave may, therefore, be called a *teron*, or a *baroteron*. The barograms show that often we should also take into consideration *brachyterons*, or waves of short duration.

North America baroterons; December 1935.—The weather maps of Canada, the United States and Mexico, from December 2 to 7, 1935, have been used to draw isallobars (figs. 2, 4, 6, 8, 10). The differences from date to date are given in hundredths of an inch.[4]

The first map, December 3 shows, a katoteron extending from Quebec, across the States, to La Paz at the southern end of the Californian peninsula (fig. 2). Differences of −38 are observed at Parry Sound, Ontario, and Davenport, Iowa. But from Aklavik, west of the mouth of the Mackenzie River, the axis of another katoteron extends in a southeast direction, to Helena, Mont. Thus, the intercrossing of terons cannot be doubted.

During the day the northeast–southwest katoteron moved eastward. On the 4th (fig. 4) it extends from Newfoundland and Labrador, along the Atlantic coast and down across Mexico, to the Pacific. The eastward displacement continues. However, the northwest–southeast axis of the V-shaped katoteron of the 5th (fig. 6) has on the 6th (fig. 8) become an all-dominating axis of negative values extending from Alaska to the Yucatan peninsula.

On the 7th (fig. 10) the displacement continues, but with a rotary movement; now the axis of the katoteron extends almost north-south, and similarly with the eastern anoteron.

A comparison with the weather maps shows, first of all, that terons move faster than LOWS and HIGHS. This fact is well known; and the deduction that the changes of pressure from day to day are primarily due to displacements of air masses at higher atmospheric levels has been developed by Ekholm, Ficker, and others.

On the other hand, the intercrossing of terons could have been deduced a priori from the wave frequency referred to before, fewer waves per unit of time in the Antarctic than in the Sub-Antarctic regions: Let us say, Framhein, 6; Belgica, 5; South Orkneys, 4; and Kerguelen, 3 days.

Naturally, one may be led to ask whether LOWS and HIGHS may not be due, in many instances if not always, to the intercrossings of katoterons and anoterons? This question should be considered with great care, since it implies that cold and warm fronts, and the shifting of wind directions, observed at the bottom of the atmosphere are the consequences, and not the causes, of the pressure changes registered on weather maps. However, the study of thermoterons justifies the view that the formation of LOWS may be the consequence of intercrossings of katoterons.

North American thermoterons: December 1935.—For Europe, maps of isallotherms have been published by Defant,[5] who found that generally the areas of increase of pressure correspond to those of decrease of temperature.

Schedler has shown that these conditions relate to the lower atmosphere, up to about 3 km., and to the substratosphere, between 10 and 12 km. of altitude; whereas between 3 and 9 km. an increase of temperature corresponds to an increase of pressure.[6] This led Schedler, Defant, and others to the conclusion that the pressure changes observed at the earth's surface are a direct reper-

[1] R. Merecki: Klimatologia ziem polskich, p. 200. Warszawa 1914.
[2] Inst. Geoph. Met. Univ. Lwow, Comm. v. 8, p. 174. Lwow 1936.
[3] Met. Zeit. Hann-Band, p. 288, Braunschweig 1906.

[4] Isallobaric maps have been regularly used by the U. S. Weather Bureau in their forecast work since 1872, although they have not been published and little has been written concerning them. See MONTHLY WEATHER REVIEW, March 1916, p. 132: On Pressure Change Charts, by Edward H. Bowie. Vol. 44.
[5] A. Defant: Wetter und Wettervorhersage, 2 Aufl., p. 159. Leipzig 1926.
[6] A. Schedler: Beitr. z. Phys. d. freien Atm., v. 7, p. 88. München 1917.

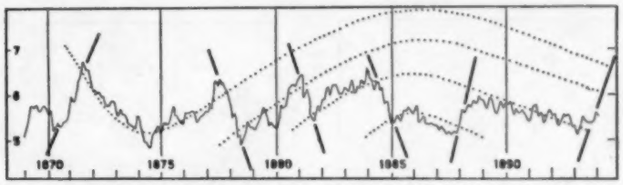


FIGURE 1.—Pressure wave-length variation in Warsaw. Consecutive 12-monthly means.

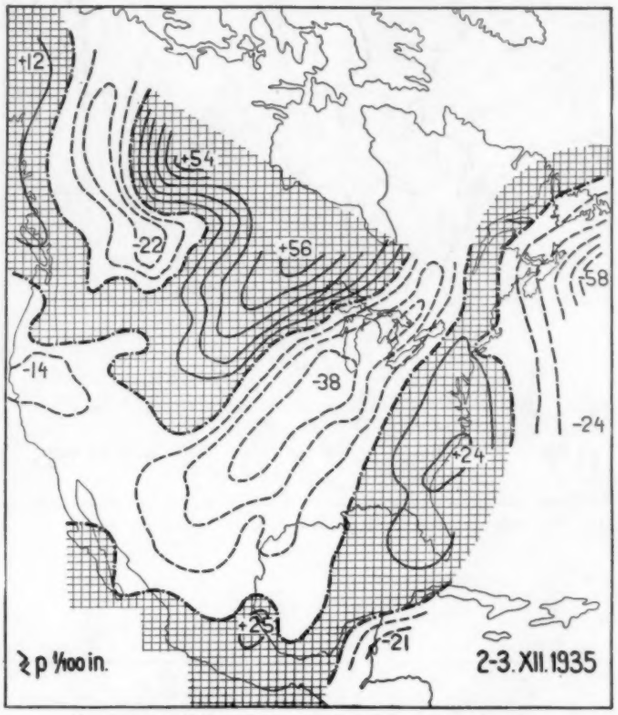


FIGURE 2.—Isallobars for December 3, 1935, over North America.

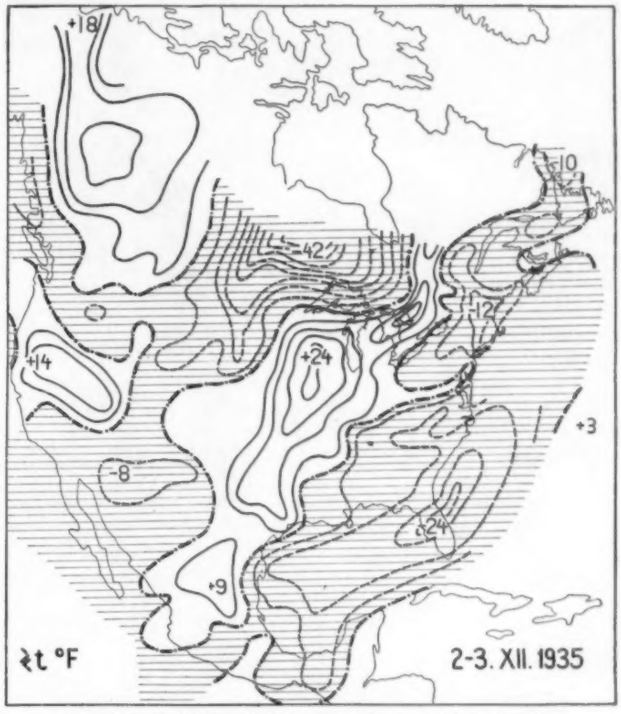


FIGURE 3.—Isallotherms for December 3, 1935, over North America.

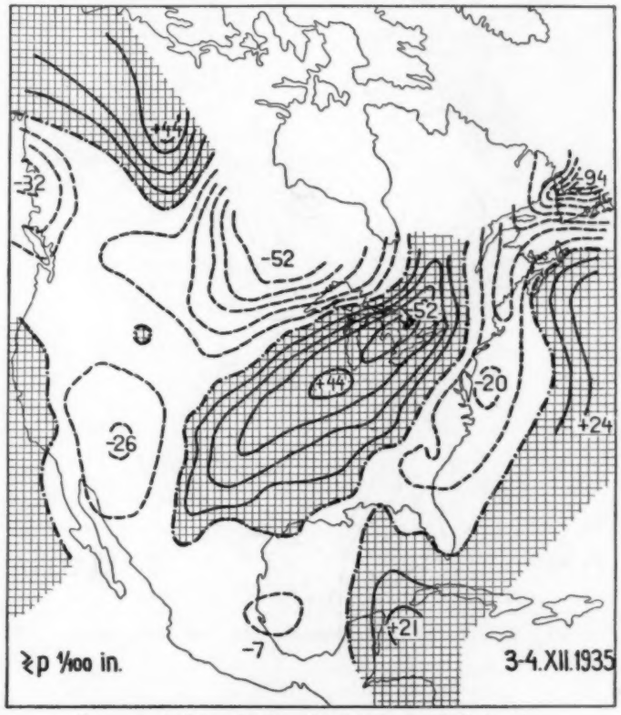


FIGURE 4.—Isallobars for December 4, 1935, over North America.

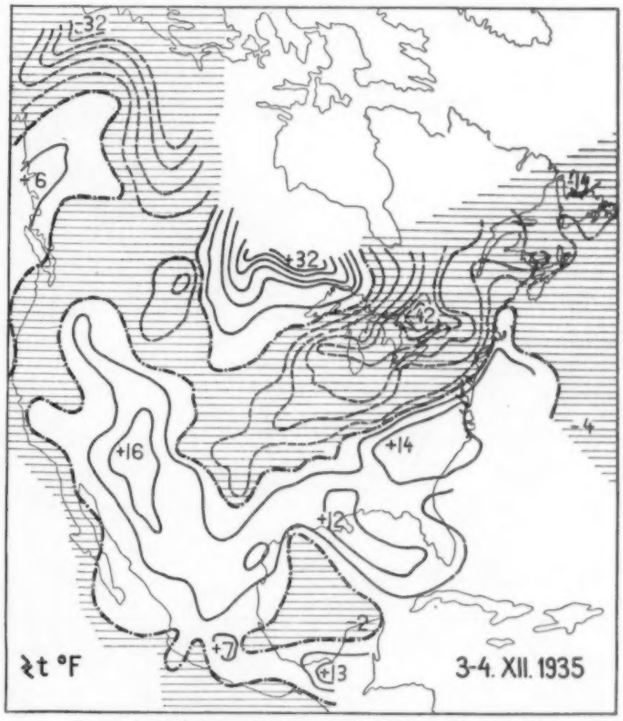


FIGURE 5.—Isallotherms for December 4, 1935, over North America.

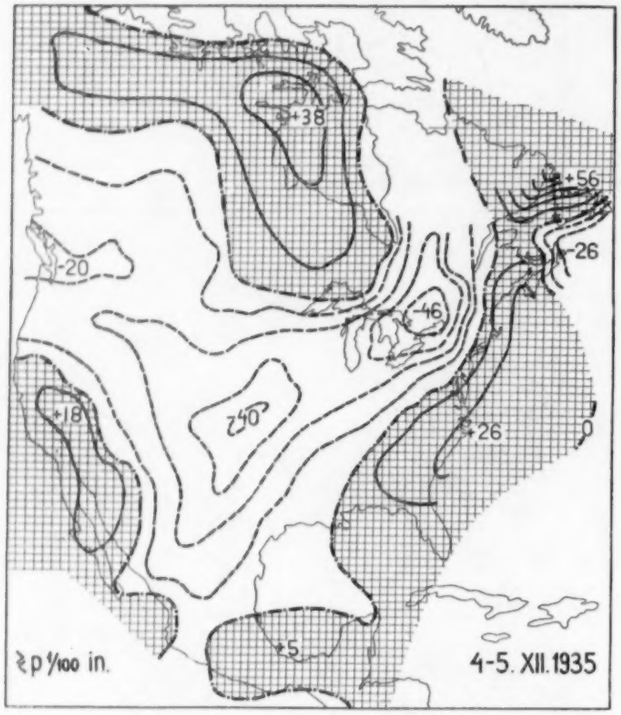


FIGURE 6.—Isallobars for December 5, 1935, over North America.

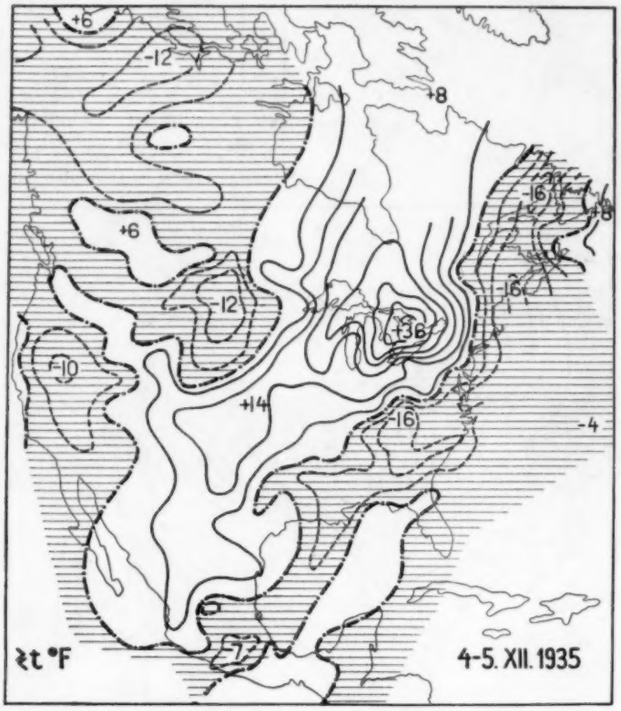


FIGURE 7.—Isallotherms for December 5, 1935, over North America.

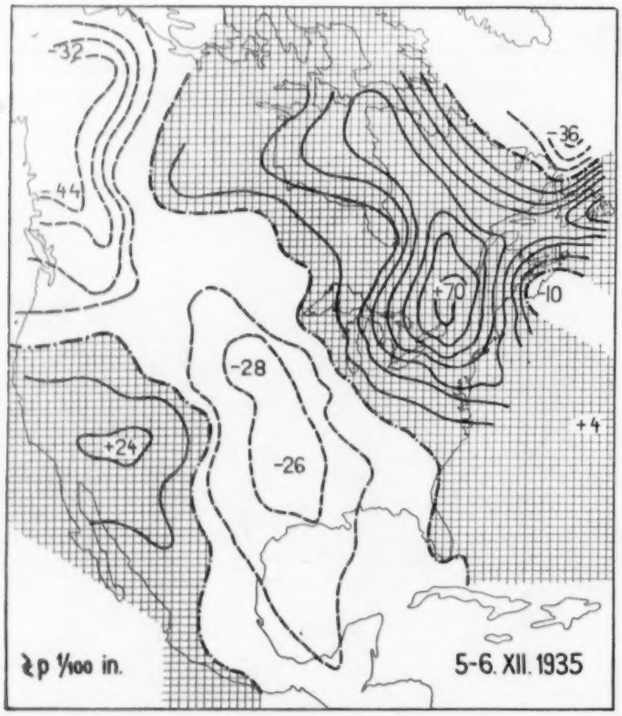


FIGURE 8.—Isallobars for December 6, 1935, over North America.

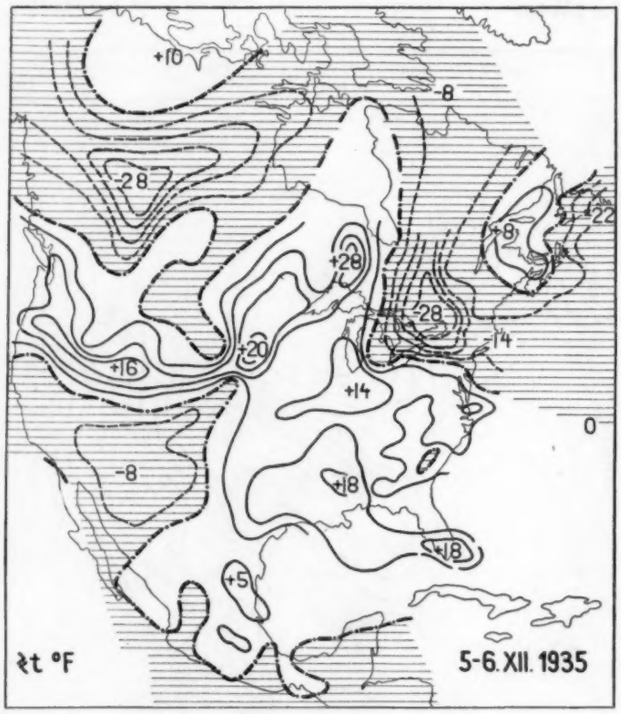


FIGURE 9.—Isallotherms for December 6, 1935, over North America.

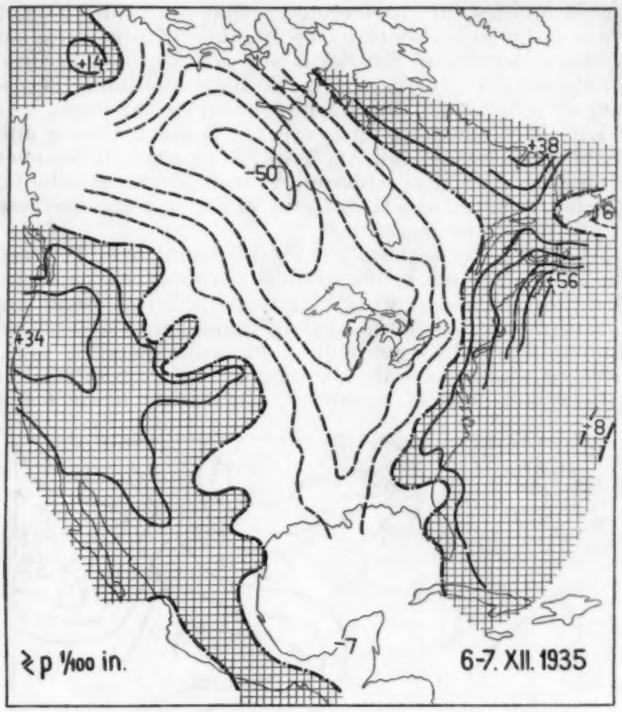


FIGURE 10.—Isallobars for December 7, 1935, over North America.

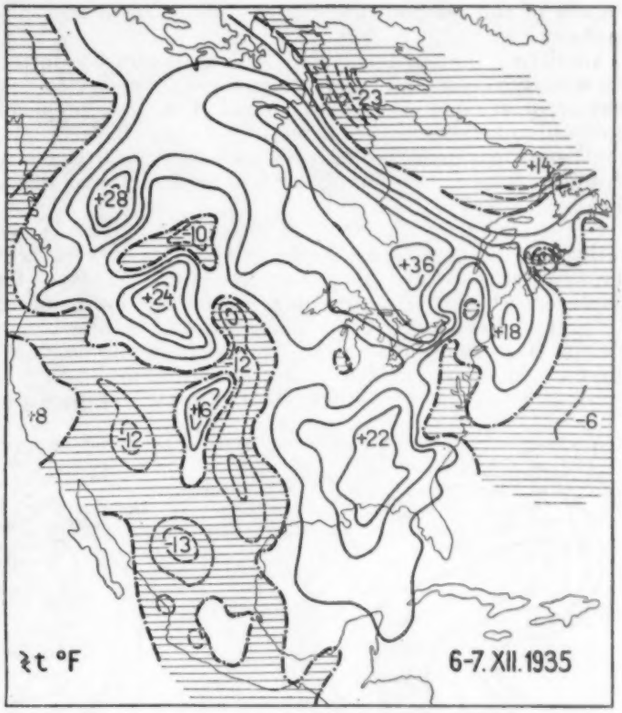


FIGURE 11.—Isallotherms for December 7, 1935, over North America.

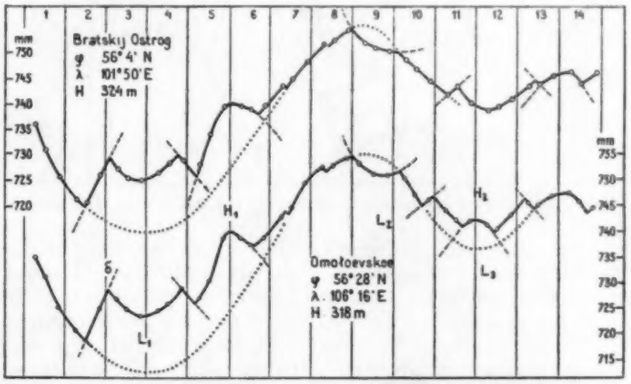


FIGURE 12.—Pressures observed January 1-14, at Bratskii Ostrog and Omoloevskoe.

cussion of the temperature changes observed in the substratosphere.

Admitting that in the United States, especially during the winter months, temperature changes from day to day may depend upon changes of wind direction, maps of thermoterons should be carefully compared with the weather maps; such comparisons show at once that many striking temperature changes may be easily explained. (See figs. 3, 5, 7, 9, 11.)

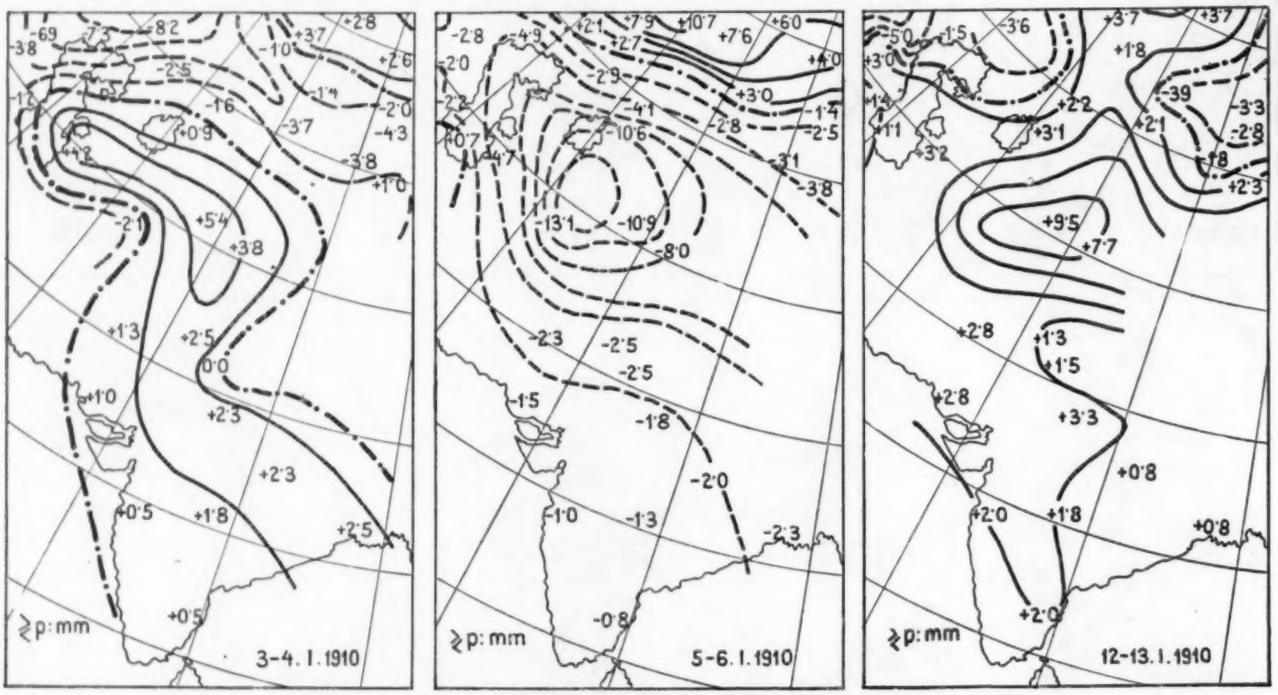
For example, on the map of December 3 (fig. 3), we notice that at Tampa, Fla., a decrease of 24° F. occurred; the weather maps will show that, under the influence of a displacement of the center of a HIGH from Fort Smith, Ark., to Asheville, N. C., a strong wind was blowing in Tampa from the south on the 2d, and from the north on the 3d. Farther north, at Cape Hatteras, no change of wind direction occurred, and the morning temperature was 12° lower on the 3d perhaps because the wind continued to blow from the north for more than 24 hours. A decrease of 10° at Belle Isle (between the northern Cape of Newfoundland and the coast of Labrador) can again be easily explained: southwest wind the 2d, north on the 3d.

Russian data: January 1910.—The barometric observations at the Russian stations for 7, 13, and 21 o'clock (local time) have been used to draw maps of the differences from day to day. The same has been done for the morning observations in western Europe, Iceland, the Azores, and North America.

At the longitude of Irkoutsk the clock is 7 hours in advance of Greenwich time. But the deformations of the isallobars, due to this fact, are progressive, going east or west; and since day after day they are similar, the maps are comparable. Making the comparisons, step by step, it seems that the 90 Russian maps for January 1910 should have been sufficient to show the progressive displacements of the pressure waves and, in the case of intercrossings, to permit of explaining the deformations or discontinuities of baroterons. However, this is not always the case, because the number of observational points, especially in Siberia, is not sufficient and because a detailed study of barograms is often absolutely necessary to understand the changes shown on the maps.

Let us compare the diagrams for Bratskii Ostrog and Omoloewskoe from January 1 to 14 (fig. 12). It becomes evident at once that errors might result from considering differences of not less than 5 mm. of increase and decrease of pressure to be waves.

At Omoloewskoe the differences of about 8 mm., between the 2d and the 3d, is due to a discontinuity in the variation, and not to a wave. L is an uplifted minimum, L_2 a depressed maximum, and L_3 again a slightly uplifted minimum. If L_3 were a minimum corresponding to L, then we should have to deal with a wave of 8 days; but at L_3 a maximum H_2 interferes, which is the direct result of a HIGH, whereas at Bratskii Ostrog the minimum is simply uplifted. H_1 and H_2 are only 6 days apart. These two maxima may belong to an intercrossing wave.



FIGURES 13, 14, and 15.—Isallobars for Turkestan and India, January 4, 6, and 13, 1910. (Differences of pressure in mm.)

Of two intercrossing wave motions, one or both of them may be composed of a succession of shorter waves. Discontinuities of cloudiness are often shown by Al.-Cu.; and the statoscope registers the small amplitudes of the discontinuities of the barometric curve going up or down.

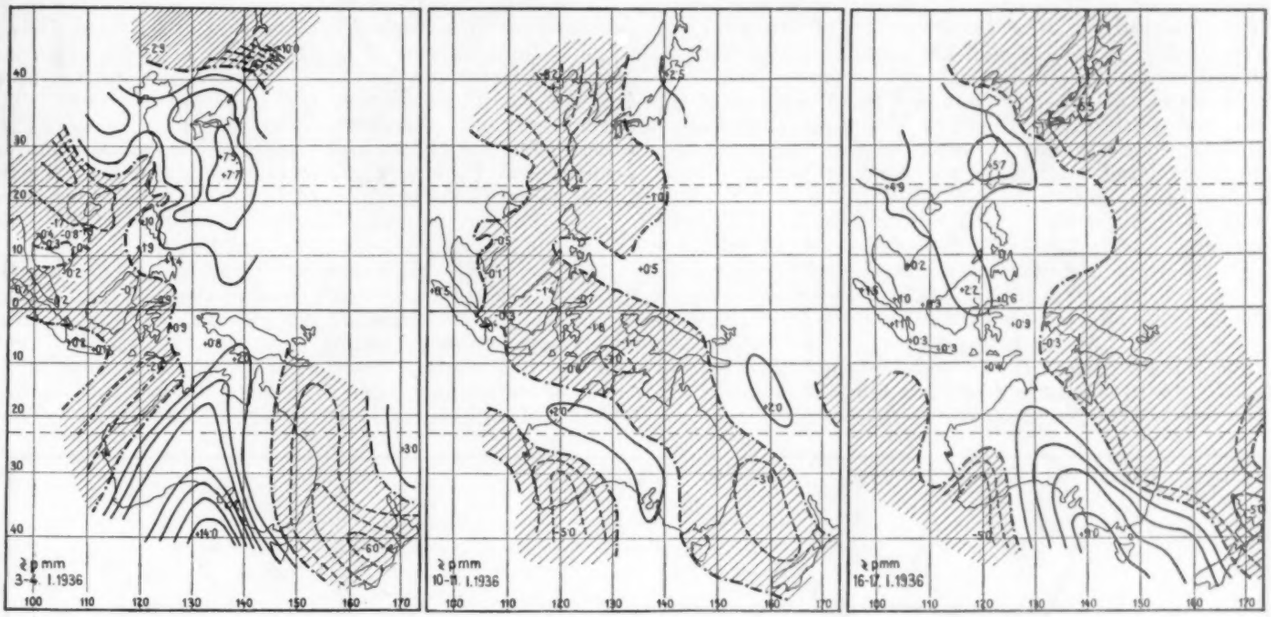
The progress of the waves may be slow in one case, less slow in the other; they may involve different levels of the atmosphere. The progress of a teron may be temporarily delayed at one end, accelerated at the other end.

The pressures registered at a given station must be a resultant of the pressures of different air masses, all in motion; the succession of LOWS and HIGHS, or of terons, can never be regular, and it is useless to try to simplify things by theoretical considerations.

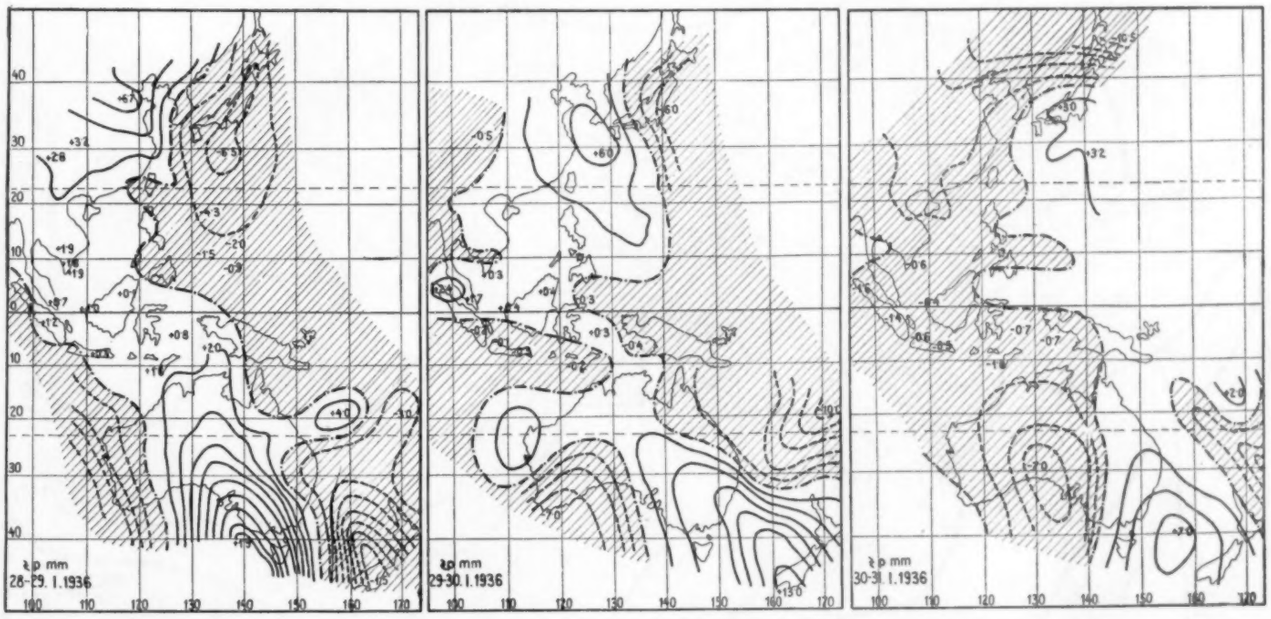
The Russian maps of isallobars are instructive mainly because they show plainly the crossings of baroterons, ir-

regularities of progress, forward and backward displacements and, above all, the fact that discontinuities of variations should exist simply because every excessive Asiatic pressure maximum goes down by steps, due to European or Arctic reactions.

the Balkans, Cyprus, Palestine, and Transcaucasia. Along the 25th meridian the axis of the anoteron of increasing pressure has been shifted north of the Black Sea. A radical change of displacement and direction of the teron is in progress.



FIGURES 16, 17, and 18.—Isallobars for China and Australia for January 4, 11, and 17, 1936. (Differences of pressure in mm.)



FIGURES 19, 20, and 21.—Isallobars for China and Australia for January 29-31, 1926. (Differences of pressure in mm.)

Across Europe and Asia, we may observe anoterons and katoterons extending west–east and moving south or sometimes north. The maps of January 6, 7, and 8, 1910, may be taken as examples. On the map of the 8th there is an axis of negative values extending from Iceland over Scotland to Poland. On the 9th the barometer also falls in

Another selection of maps shows north to south waves moving from west to east. A fall of pressure of 30 mm. from the 23d to the 24th, observed in England, belongs to a katoteron extending from the Arctic circle at least as far south as Madeira. On the 25th the axis of the katoteron goes from the Arctic regions, through Lapland, Central

Europe and across the Alps and the Mediterranean, to Algeria and the Sahara. On the 26th, a narrow axis of negative values extends from Scandinavia to Greece. By the 27th it moved farther east.

It should be useless to describe these maps in detail. The barograms of many stations should be compared with the maps in order to make an interpretation of the details of the observed pressure variations. The study of the distribution of rainfall should be the principal purpose of such researches.

Pressure changes in Turkestan and India.—North of the Pamir and south of the Himalaya Mountains the pressure changes from day to day are often similar. Isallobars for India are related to those of the Turkestan and Siberia. (See figs. 13, 14, 15.)

The most important wall of mountains in the world, separating Asiatic Russia from India, does not influence the distribution and displacements of terons—just as if the lower atmospheric strata (below an altitude of about 5,000 m.) were affected mainly by the pressure changes occurring above. At least this is true for the baroterons during January 1910. The anoteron on the 13th, extending from 70° to 10° latitude, from Novaiia Zemla to Ceylon, may serve as example (fig. 15).

Detailed isallobaric maps of India have also been drawn for January 1934 and October 1935, making use of all the 8 o'clock data of the daily weather maps. In most cases the changes of pressure from day to day, as shown on these maps, must depend on those of Turkestan and central Asia.

The maps from October 13 to 23 are of particular interest because of a tropical cyclone that crossed the Decan. The isallobaric map of the 16th and 17th shows an isolated katoteron north of Ceylon, and also negative values in the Punjab as far as the northwest frontier. The decrease on the 18th was highest at Madras, and at the same time the katoteron of the Punjab spread out over the central Provinces. The map of differences for the 19th shows the entire area of India occupied by negative values. From then on, the barometer continued to fall until the 23d in northern India and Burma.

This example leads to many questions concerning the ultimate relations between tropical cyclones and terons.

China and Australia: January 1936.—In order to draw isallobaric maps extending from the 40th parallel north to the 40th south, pressure data from 11 stations in the Dutch Indies have been added to those of the synoptic charts of Indochina, Hong Kong, and Australia. These

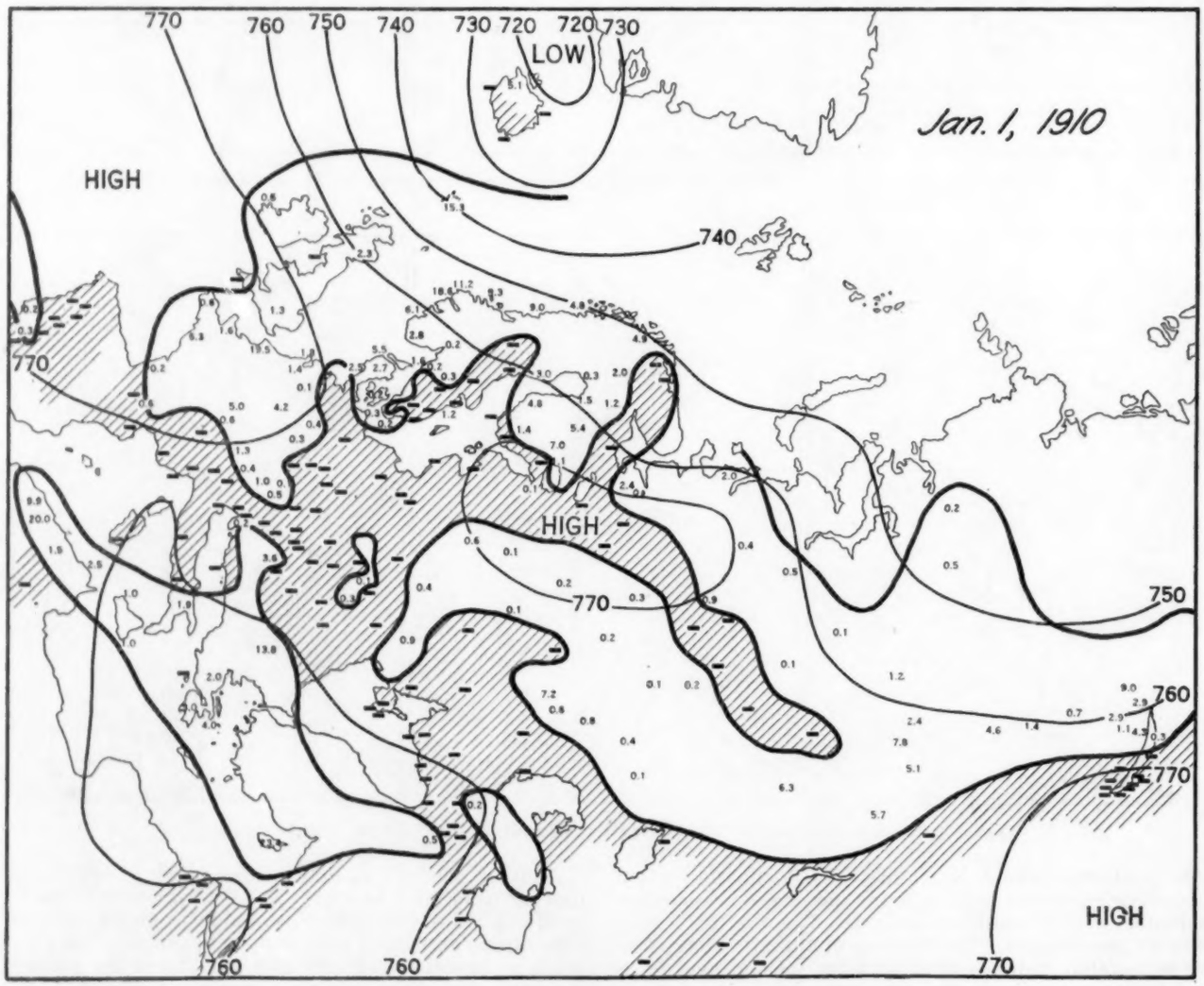


FIGURE 22.—Precipitation areas, January 1, 1910. Heavy dashes indicate observed zero precipitation (shaded area).

maps show that anoterons and katoterons often extend across the Equator from one hemisphere to the other.

The maps of pressure differences of the 4th, the 11th, and the 17th (figs. 16, 17, 18), and those of the 29th, 30th, and 31st (figs. 19, 20, 21) may serve as examples.

During the year 1882 a total rainfall of 2,460 mm. was observed in Batavia, while for 1891 it was 1,166 mm.—more than double for a year of maximum than during a year of minimum of rainfall.

Since the frequencies of pressure waves (of 5 or more mm. amplitude) observed in Warsaw differ greatly from year to year, we may admit, a priori, important changes of the mean amplitudes and frequencies of baroterons, all over the world. Simultaneity of maxima or minima is not to be expected.

If any relation exists between the frequency and quantity of rainfall and the frequency and amplitude of baroterons, it is possible that such a relation will be best observed in equatorial regions. Investigations of the phenomena in Batavia gave promising results.

Rainfall and baroterons: January 1910.—Although it seemed improbable that any simple relation between katoterons and diurnal rainfall areas should exist, maps were drawn for January 1910, using all available Russian data and those of a number of other European stations.

These maps were compared with the pressure maps of the Northern Hemisphere published by Exner,[7] and with those of the isallobars described before. See figures 22, 23, 24.

It is evident that, in general, rainfall of a given date occurs only during some particular hours of that day; and there are different kinds of rainfall. Comparisons should therefore be made with pressure changes for the hours during which rain fell, and for each kind of precipitation separately.

The rainfall areas, however, disagree with the distribution of pressure in so many cases and in such a striking manner, and so often do not occur where they should according to theory, that a detailed study of the rainfall maps seems desirable.

For example, the map of January 1 (fig. 22) shows three wide strips of rainfall, extending west to east, one from the

[7] Felix M. Exner: Karten der atmosphärischen Zirkulation auf der Nördlichen Halbkugel vom 1. Januar bis 31 März 1910. Wien 1929.

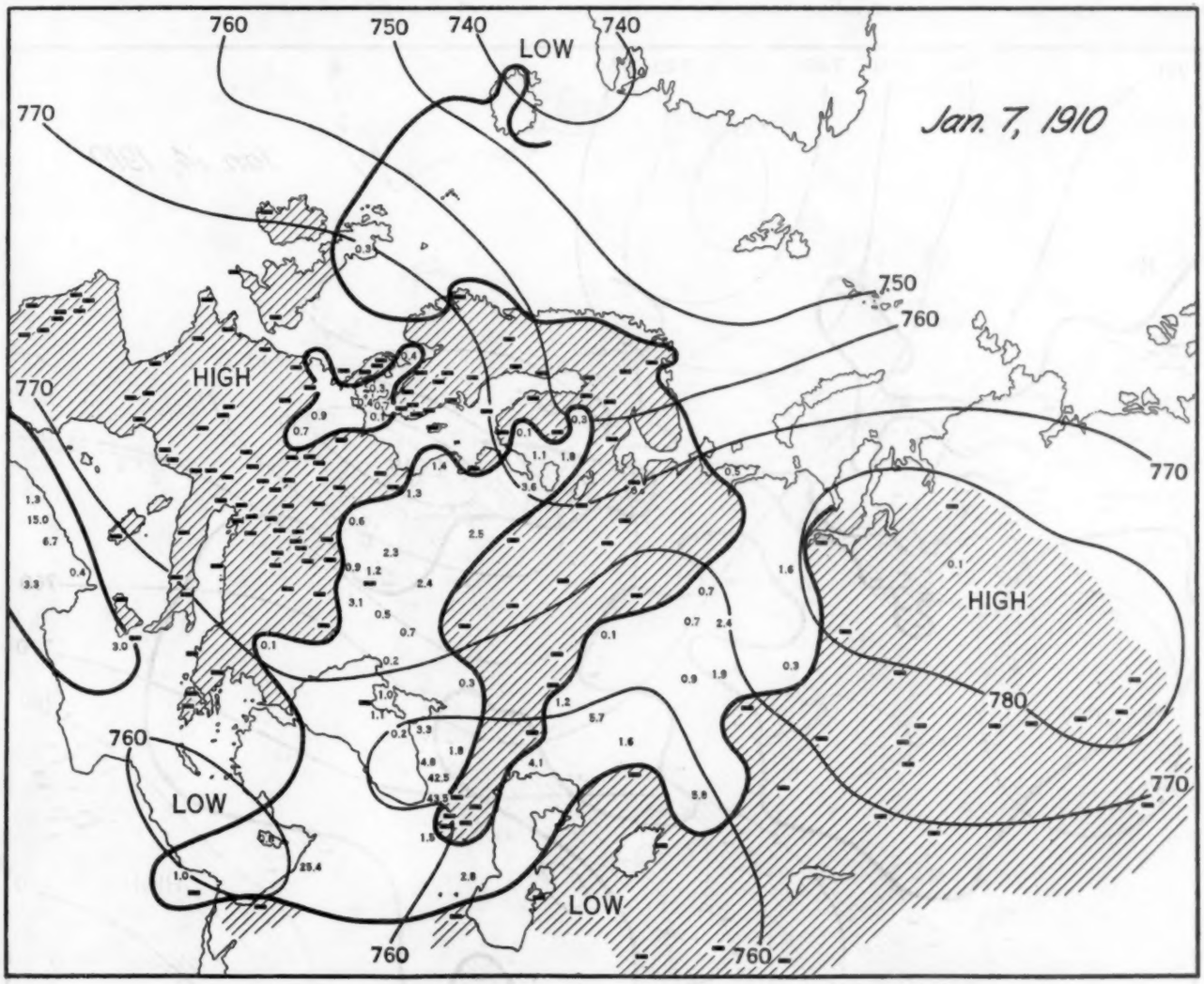


FIGURE 23.—Precipitation areas, January 7, 1910. Heavy dashes indicate observed zero precipitation (shaded area).

White Sea into Arctic Siberia, the second along approximately the 55th parallel from 30° to 115° longitude east, the third from Algeria across Sicily and Greece to Cyprus. Neither isobars nor isallobars will explain this fact.

The map of the 7th (fig. 23) may be taken as another characteristic example of which a study should be made. It shows one wide strip of recorded rainfall from Finland down to the Black Sea, and another from Novaiia Zemla down to the Caspian Sea, both going across the continental axis of high pressure of that date.

Most of the rainfall maps show such strips of precipitation, more or less independent of the pressure distribution, but offering in a sufficient number of cases enough anologies with the isallobaric maps to tempt one to speak of ombroterons.

The 14th (fig. 24) may be taken as an example. The high-pressure areas of central Asia and of the Azores are connected. Two LOW centers, one near Iceland and the other on the sea of Kara, make the isobars extend in a general east-west direction; while across Europe and Asia, in a north–south direction, across the continental axis of high pressure, five strips without rainfall, and five elongated embroterons, just like pressure waves, are recorded. The rainfall area extending from the North Cape to Greece is connected with a west Mediterranean-Black Sea rainfall axis.

Comparison with the map of isallobars supports the hypothesis of correlation.

As has been seen on the curve of Omoloevskoe discussed before, isallobaric maps based on intervals less than 24 hours should show pressure differences due to discontinuities of variations. This leads to the working hypothesis that ombroterons are the product of reactions of fronts of discontinuity in baroteronic air mass displacements in the lower atmosphere.

The comparison of the maps of isallobars show tendencies toward increasing or decreasing anoterons or katoterons during a succession of days. This fact must be due to transport of air masses over periods of successive days.

Maps of differences of 10-day means, as well as of monthly means, show these world displacements of pressure excesses or deficits quite well. The same may be said about the annual means and the means of lustra of years.

Abnormal seasons of a given year, or the anomalies of a month or two, may therefore depend upon certain tendencies of climatic variations.

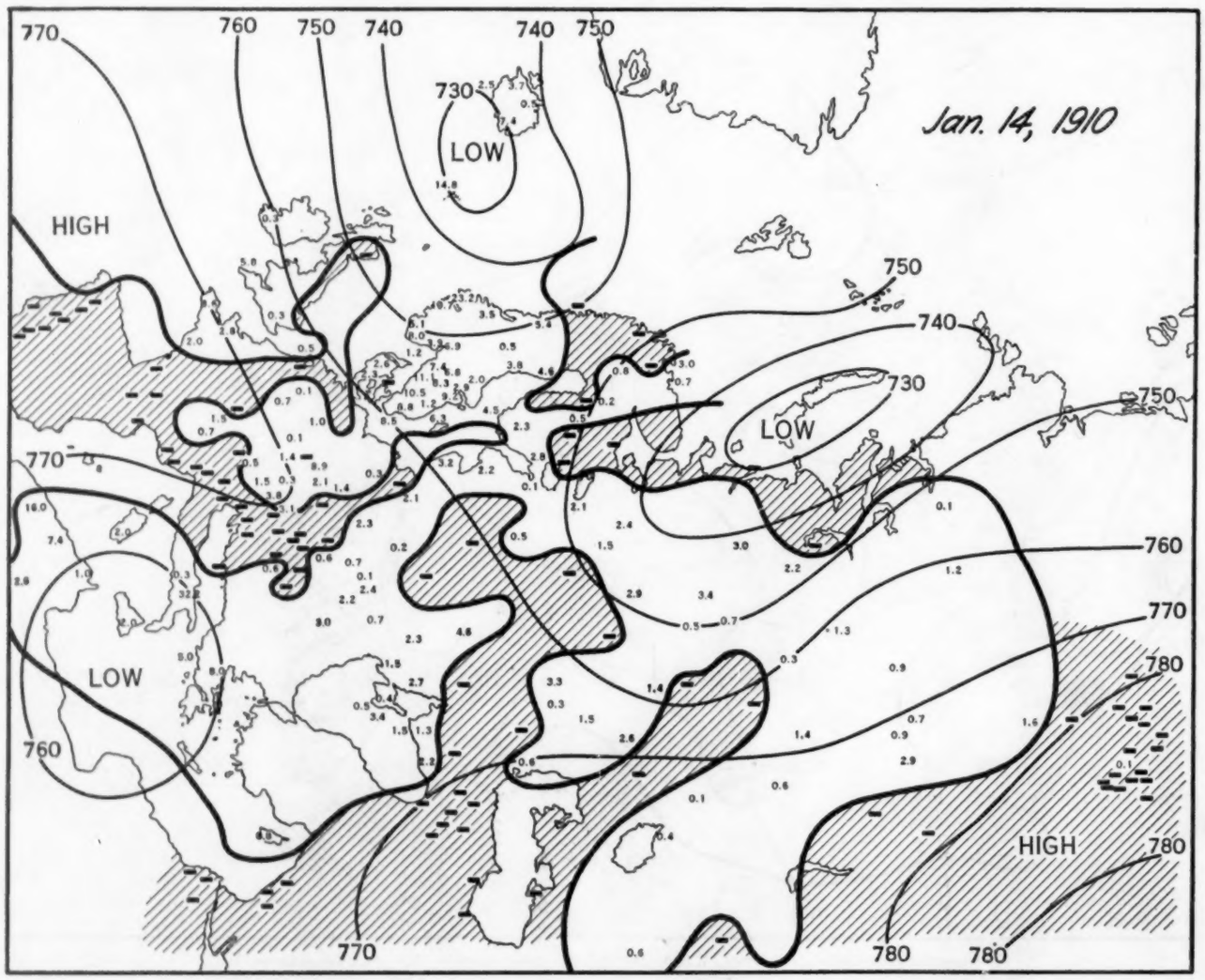


FIGURE 24.—Precipitation areas, January 14, 1910. Heavy dashes indicate observed zero precipitation (shaded area).

METHODS AND RESULTS OF OZONE MEASUREMENTS OVER MOUNT EVANS, COLO.

By R. STAIR and I. F. HAND

[National Bureau of Standards and U. S. Weather Bureau, Washington, D. C., September 1939]

This paper gives data on the total amount of ozone above Mount Evans, Colo., during the latter part of July 1936 and 1938, as determined from ultraviolet measurements by a photoelectric cell and filter method. The method, especially the calibration of the photoelectric cells, is discussed in detail. The measurements indicate ozone in the stratosphere in the amount of 0.20 to 0.22 cm. normal temperature and pressure, which is in good agreement with determinations by others for the same latitude and season of the year.

Incidental to the work, a new determination of the solar energy curve in the short ultraviolet wavelengths outside the earth's atmosphere is made.

I. INTRODUCTION

The usual method employed in the study of the total amount of ozone above a given point has been that of measuring the intensity of the solar radiation at one or more wavelengths within the ozone absorption band, that is below 3200 angstroms, relative to some longer wavelength or wave lengths outside the region of ozone absorption. Ordinarily a photographic method is utilized; and measurements are made at two or more different air masses (air mass equals approximately the secant of the sun's zenith distance) and upon the assumption that both the ozone content and solar emission remain constant during the interval.

It is doubtful if either the ozone or the solar energy remains constant for a very long period; and both are thought to change in cycles, the ozone with the season (**1**) and the solar emission with the sunspot cycle. Short periods of variation of the order of days and hours have been noted by others and also appear in the results of our own work at Mount Evans, where there was observed a definite variation in the filter transmissions, indicating a variation in either (or both) the ozone content or the spectral quality of solar emission in the ozone band. It would be very difficult to separate the two effects, and it is questionable if any of the present methods are sufficiently sensitive to accomplish this result. However, the effect of any change in solar emission within the range of wave lengths reaching the earth's surface, even upon a mountain top, is much less than that of the ozone, and for the present may be neglected without making a serious error in the determination of the ozone.

It has been recognized by others (e. g. by Götz who made some filter measurements), and was pointed out in connection with the report on some stratosphere measurements (**2**) at the National Bureau of Standards in 1937, that it should be possible to follow the ozone cycle through the year and from year to year by means of photoelectric cell and filter measurements. However, owing to certain difficulties, especially the lack of time to work out sufficiently accurate methods for the calibration of the spectral response of the photoelectric cells, no definite progress along these lines was made until recently (**12**), when a preliminary report on this work was prepared and given before the April 1939 meeting of the Meteorological Section of the American Geophysical Union in Washington, D. C. It is a relatively simple matter to get qualitative measurements of ozone variation by this method, but accurate quantitative values require a careful evaluation of the photoelectric response, especially in the longer wave lengths to which the cell responds. These wave lengths, owing to their higher intensity in sunlight, produce a large part of the total photoelectric response of the cell.

Furthermore, the conditions at Washington, D. C., low altitude and high humidity, militate against the study of the amount of ozone in the stratosphere from a ground station because of variations of atmospheric transmissions in the lower levels of the atsmosphere, below 10,000 feet, caused by dust, smoke, etc. Measurements at high altitude minimize errors that are inevitable through the more vitiated lower atmosphere; hence, the present report deals only with measurements on Mount Evans above 10,000 feet in elevation in 1936 and 1938.

Unfortunately, neither the observing period in July 1936, nor in July 1938, comprised many clear days. In 1936, when the measurements were made by the senior author at Echo Lake (altitude 10,600 feet, on the north slope of Mount Evans) only 1 of the 10 days spent there remained practically cloudless throughout the day. On 4 other days measurements were obtained during part or all the morning. The afternoons were cloudy and there was usually rain, and on 3 days sleet and snow in the late afternoon. A view of Echo Lake is shown in figure 10.

On the peak of Mount Evans (altitude 14,260 feet) in July 1938, when the measurements were made by the junior author, high clouds or broken cumuli prevailed during the morning hours. On 8 of the 9 days spent at the crest, the cloudiness increased shortly after noon, on some days with great rapidity, and on all 8 days was followed by rain, hail, sleet, and snow; generally in the order named. We were fortunate, however, in having less trouble from static than had been anticipated; we had prepared for possible difficulties by observing with both our instrumental equipment and bodies well grounded by copper wire to avoid undesired fluctuations of the current in the measuring instrument. At times the potential gradient is so strong on Mount Evans that not only is the reading of electrical equipment impracticable, but the observer has to take advantage of the copper-roofed and copper-sided observatory to avoid uncomfortable sparking from his body to the ground. Views of Mount Evans and the observatory are shown in figures 12 and 13.

The method herein described of obtaining the amount of ozone in the stratosphere makes use of titanium photoelectric cells and filters as described in the paper by Coblentz and Stair (**3**) on studies of ultraviolet solar intensities. For this work, however, as noted above, a much more elaborate calibration of the photoelectric cell for spectral response and of the filters for spectral transmission is required than was used in the preliminary study of total solar ultraviolet intensities.

Since the major part of the work of a research of this type consists of an accurate determination of the spectral response of the photoelectric cells, the transmissions of the filters and the mathematical evaluation of the data, and since the method is a modification of that employed in the determination of the distribution of ozone in the stratosphere (**2**), a considerable portion of this paper is given to a discussion of the general method, especially the spectral calibration of the photoelectric cells.

Suggestions concerning improvements in certain phases of this type of work, especially in the method of obtaining

the data are given where avoidance of mistakes is especially helpful.

II. THE PHOTOELECTRIC CELLS AND FILTERS

In this work four titanium photoelectric cells [1] and four filters (Corex D; Nillite; Barium Flint, 1 mm.; and Barium Flint, 3 mm.) having the spectral responses and transmissions depicted in figure 1 were employed. Cells Nos. 2 and 6 were used in 1936 and Nos. J–4 and D–6 in 1938. Two sets of filters, alike in ultraviolet spectral transmission were employed in this work; and several tests, before and after their use, established their constancy and agreement in transmission. The same filters were used also in the photo-electric calibrations with the Mazda CX lamp, described in section 2. Their transmissions

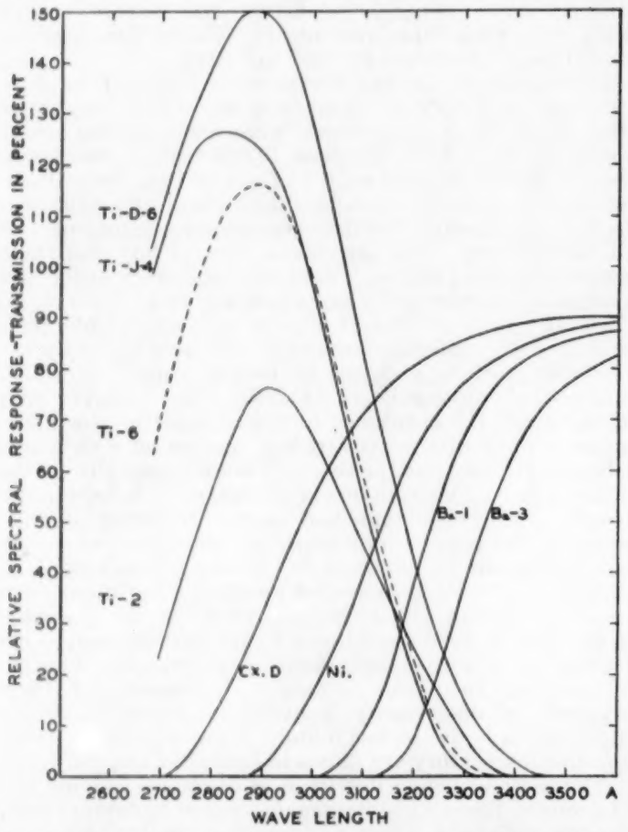


FIGURE 1.—Graphs showing the relative spectral response curves for the four titanium photoelectric cells; also the spectral transmissions of the filters.

were determined at the wave lengths of the mercury emission lines and the shapes of the curves between points adjusted for best agreement with calculations on other thicknesses of glass and integrated transmission magnitudes as calculated from their use with the Mazda CX lamp. Consequently, any errors will be partly balanced out by the fact that the Mazda CX lamp has a spectral energy emission curve in the ultraviolet spectrum somewhat similar in shape to that of sunlight. (See figure 2.)

1. *Spectroradiometer calibration of the photoelectric cells.*—The spectral response of the photoelectric cells was obtained by two supplementary methods; the first of these being the commonly employed, spectroradiometric method, in which the strong emission lines of a mercury arc lamp and a cadmium arc lamp are used to obtain an equal energy response at the wave lengths of the emission lines. In this calibration the same slit defined the energy for the photoelectric cell and for the thermopile, the two being moved alternately behind the slit. In the spectral calibration of photoelectric cells by this method, the irradiated portion of the cell shifts slightly with wave length because of variation in focus and angle of emergence of the radiation; so that as the result of unequal sensitivity, or shadowing by the central electrode within the cell, erroneous values may result. Several measurements with different adjustments of the cells, however, partly neutralized these effects.

This method of calibration is consequently not sufficient, especially for wave lengths longer than 3,200 angstroms, which is close to the wavelength limit of sensitivity of the cell. It was especially difficult to define the response between the wavelengths 3,261 and 3,404 A. (cadmium arc lamp emission lines) for the titanium cells used in this study. A slight variation in the curvature of the response curve between these points produces a marked effect upon the total integrated transmission values of the

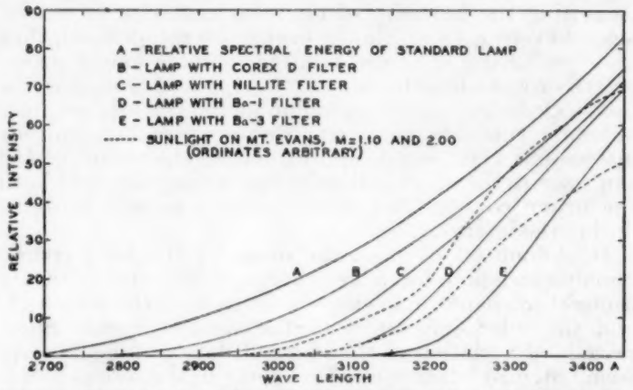

A – RELATIVE SPECTRAL ENERGY OF STANDARD LAMP
B – LAMP WITH COREX D FILTER
C – LAMP WITH NILLITE FILTER
D – LAMP WITH Ba-1 FILTER
E – LAMP WITH Ba-3 FILTER
SUNLIGHT ON MT. EVANS, M=1.10 AND 2.00 (ORDINATES ARBITRARY)
RELATIVE INTENSITY
WAVE LENGTH
2700 2800 2900 3000 3100 3200 3300 3400 A

FIGURE 2.—Graphs showing relative spectral energy curves of the standard lamp and of the sun. The curves for the lamp are greatly magnified relative to those for the sun.

filters. Since the response at 3,404 A. was of the order of one-thousandth, or less, of that at 2,967 angstroms for some of the cells, extreme caution was necessary in the use of exclusion and transmission filters with the spectrometer to insure freedom from stray light of other wave lengths. For this reason measurements made upon the weak mercury line at 3,340 angstroms were not satisfactory. In solar radiation, these wave lengths produce a large effect upon the total response of the cells and upon the total transmission of the filters; hence the great importance of knowing accurately the spectral response in this region. For this purpose a supplementary method of calibrating the photoelectric cells is employed.

2. *A source of continuous spectral ultraviolet radiation for calibrating photoelectric cells.*—Toward this end a standard of continuous ultraviolet radiation in the form of a Mazda CX lamp was set up. The approximate shape of the emission curve in the ultraviolet was known from data by W. E. Forsythe (**10**) on the Mazda CX type of lamp operated on 115 volts. Since this standard was a particular lamp and was operated on a slightly lower voltage (110 volts to insure longer life) these general data could not be directly applied.

By trial and error, corrections to the general emission curve [2] in the short wavelength region were calculated

[1] Westinghouse type WL–767 titanium photo-electric cells were used in this work.

[2] If a suitable black body, or even a filament lamp of known spectral emission, had been available this part of the work would have been greatly simplified.

FIGURE 10.—Echo Lake, elevation, 10,600 feet.

FIGURE 11.—Ultraviolet meter, titanium photoelectric cell, and cell mounting.

FIGURE 12.—Cumulus cloud over Mount Evans Observatory, elevation, 14,260 feet.

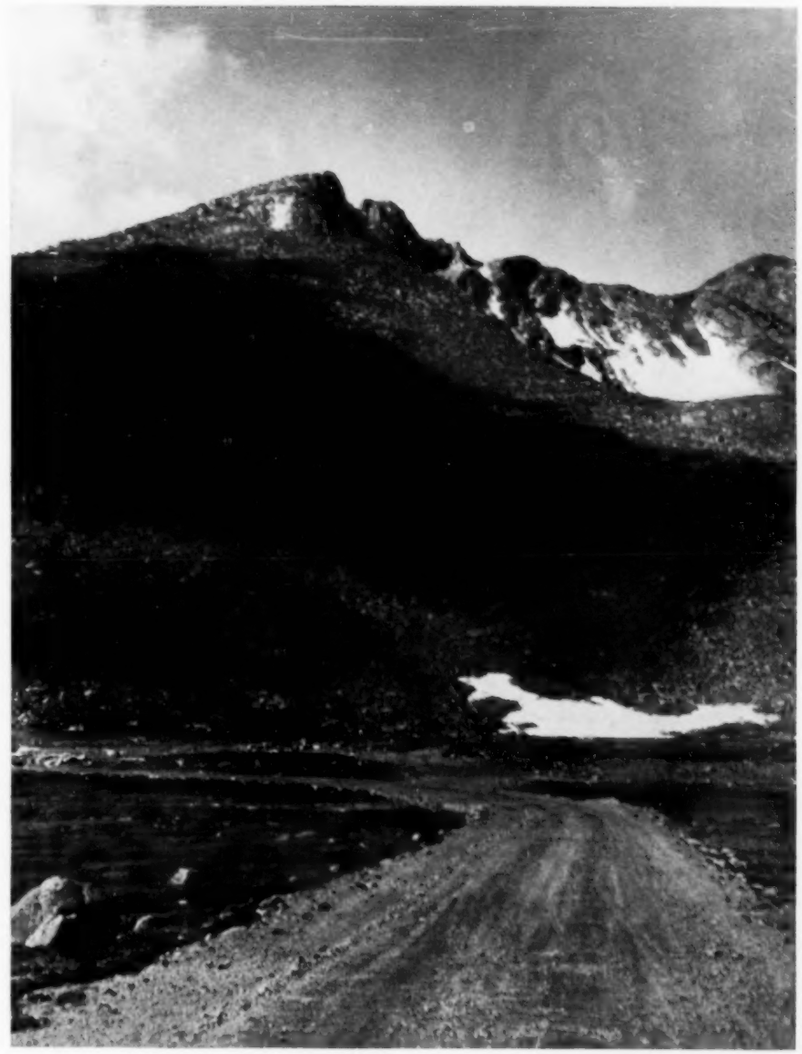


FIGURE 13.—Mount Evans peak from Summit Lake, elevation, 14,260 feet.

from the filter transmissions (the same four filters as employed in the solar measurements) using the average for eight titanium photoelectric cells which had been carefully calibrated by the spectroradiometric method and were known to have a relatively sharp cut-off at the longer wave lengths. Hence, since the shape of the lamp emission curve was already fairly well known in the longer wave lengths in the ultraviolet (above 3,100 A.) and since the photoelectric cell response curves were known quite accurately below 3,150 A. the spectral energy curve in the short wave-length region obtained by this method is, no doubt, better than could be measured directly with a spectroradiometer.

The Mazda CX lamp approximates sufficiently close for our work the solar emission in that portion of the short ultraviolet spectrum to which the photoelectric cells are sensitive, having, as does the sun, a high emission in the region where the photoelectric cells have a low response. By measuring a set of integrated transmissions of a group of calibrated filters with this lamp as a source, and by calculating the integrated transmissions of the same filters from a knowledge of their spectral transmission, the spectral energy emission of the lamp, and the spectral response of the photoelectric cell (based upon an arbitrary curve drawn through the values for the wavelengths at which the response was determined spectroradiometrically) the shape of the photoelectric cell response curve, especially between 3,261 and 3,404 angstroms and for longer wave lengths, was altered until the observed and calculated transmissions were in agreement. In this manner the shape of the spectral photoelectric response in the region of 3,200 to 3,400 A. was obtained.

In addition, for some of the cells, the apparent emission curve of the lamp was altered, by covering the photoelectric cell permanently with one of the filters, and the process repeated. That gave a new standard of continuous ultraviolet radiation with the energy curve shifted toward the longer wave lengths (see fig. 2). Since the Mazda CX lamp as used (a 500-watt, 115-volt lamp operated on 110 volts) was richer in short ultraviolet relative to longer ultraviolet wave lengths than sunlight, this modification gave filter transmissions, and hence an energy curve, approaching closer to sunlight in the spectral range 3,000 to 3,300 angstrom units. The spectral response values of the photoelectric cell were again altered, if necessary, for best agreement between the calculated and observed transmissions.

In this second method of calibration of the response of the photoelectric cell no trouble is encountered with scattered light and the cell is tested, as used in practice; that is the cell is fully and evenly irradiated.

The Mazda CX lamp method appears to be a very satisfactory means of determining the existence and magnitude of the long wavelength "tail" of the photoelectric cell response curve. For cells of certain types (not the titanium cells as used in the present work) 50 percent or more of the total response in sunlight may be due to long wave lengths at which the relative response is less than 1 percent of the maximum value and would not be detected at all, or, at best, inaccurately determined even with the most careful work by the spectroradiometer method. Although the spectral response in the long wave lengths may be only a few parts in a thousand, relative to that at the maximum for the cell, the total integrated filter transmissions may be affected by amounts which in practice would give calculated values of ozone in error by a factor of two or more.[3]

[3] A cell having an extremely broad long wavelength response should not be used in ozone determination work because of the difficulties encountered in evaluating the data when the response covers so long a spectral range.

This method of calibration of the spectral response of a photoelectric cell may be extended to include filters of both longer and shorter wave lengths cut-off, for use with other types of cells. It is of course not recommended as a sole means of obtaining response curves, but will give an approximate curve without a great amount of calculation if the approximate location of the maximum response and the general type of the response curve are known.

By measuring the filter transmissions from time to time, using the Mazda CX lamp as a source, the constancy of the relative spectral response of the photoelectric cells is checked. Although no filter measurements on our four cells had been made before the observations on Mount Evans, check measurements during the past year indicate that these cells have undergone no measurable change. Furthermore, solar observations obtained at Washington, before and since the Mount Evans work, are in agreement. Check measurements on photoelectric cells which have been used but little in the meantime also indicate that the relative spectral emission of the Mazda CX lamp has undergone no measurable change over a total operating period of about 30 hours. Since the lamp is operated on a fixed voltage (instead of amperage) below the normal working value only a very slow change is to be expected.

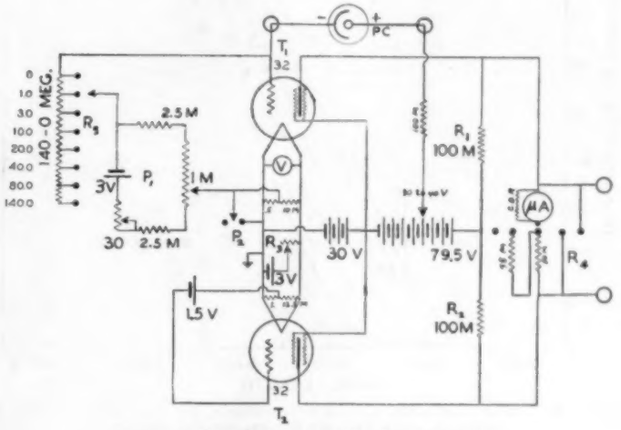


FIGURE 3.—Electrical circuit of the ultraviolet meter.

III. THE ULTRAVIOLET METER

A portable ultraviolet meter in which the photoelectric current is amplified and then measured by a microammeter was easily transported to the mountain stations. Two of these instruments, designed by one of the authors in collaboration with W. W. Coblentz at the National Bureau of Standards, and now obtainable from the Bendix Radio Corporation of Baltimore, Md., were used in the present work. The instrument, an original model (**4**) of which has been described previously, is shown photographically in figure 11 and diagrammatically in figure 3.

Briefly described, this instrument is a balanced direct-current amplifier built in the form of a Wheatstone bridge.[4] A condition of unbalance results when light falls upon the photoelectric cell producing a flow of current through a microammeter proportional to the intensity of the radiant energy incident upon the cell. Practically

[4] In reference (4) earlier arrangements of amplifier circuits involving the Wheatstone bridge principle are cited.

all the component parts are standard radio materials. All the resistors and potentiometers, except those in the grid circuit, Rg, are of the wire wound precision type. S. S. White Dental Manufacturing Co., type 65X, resistors have been found to be suitable for the grid circuit units. In the assembly all units are carefully soldered and moving elements having pressure contacts on the shafts are provided with soldered "jumpers" supplementing the pressure contacts. Even the grid batteries and tube electrodes are connected into the circuit with soldered leads.

The resistors, Rg, are mounted on hard rubber or bakelite and all connecting wires are air insulated. The photoelectric cell connecting cable is doubly insulated with rubber, ordinary rubber covered wires being pulled within a piece of chemical rubber tubing of high quality and the grid lead electrically shielded. Leakages within the cable, or photoelectric cell mounting case, are readily located by means of the deflection observed with the leads alternately connected and disconnected from the amplifier.[5]

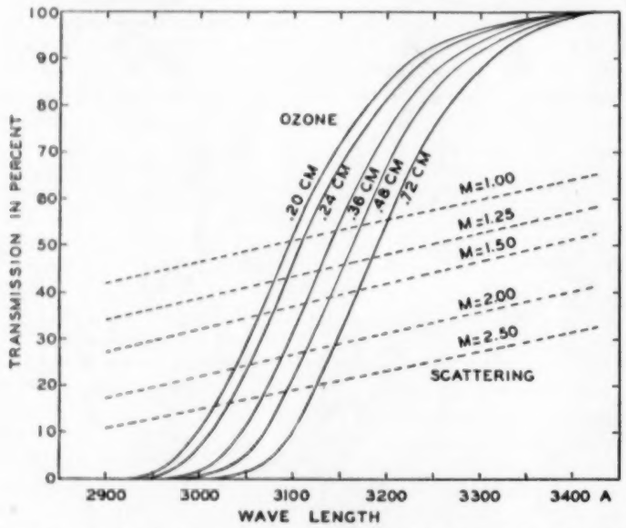


FIGURE 4.—Graphs showing the spectral transmission of the atmosphere in terms of molecular (Rayleigh) scattering and ozone absorption.

Although, not used in the present work, the instrument should contain a drying pack, especially when used in a mountain location where wide changes in temperature and humidity occur. Errors produced by moisture on the resistors and mountings of the instrument may affect the total intensity measurements seriously but not the percent transmissions upon which our ozone calculations are based. Some of the variations observed in total intensity may thus be partly instrumental error.

In performance, three instruments tested over a wide range in intensity showed a linear response to within about 1 percent. This precision is about the maximum that can be expected with electronic apparatus in which the radio tube characteristics enter in a direct way. Since the microammeter deflection was kept near the same scale value, by adjusting the sensitivity of the amplifier, the precision probably remained within 1 percent during most of the work.

With poorly balanced tubes, or tubes with high grid current characteristics, or with improper bias or plate voltages, errors in excess of 1 percent often result. Hence the authors highly recommend that in work where transmissions are desired, as in the case of ozone studies, perforated metal screens having approximately the same transmissions as the glass filters be employed as incorporated in the stratosphere ultraviolet meter at the National Bureau of Standards (**5, 13**). An addition that would be necessary with the use of perforated screens is a quartz diffusing window over the photoelectric cell. This would reduce variations in reading as the angle of the solar adjustment changed during a set of measurements. Furthermore, since the magnitude of the readings, filter and screen, would be of the same order, both could be kept near the upper end of the scale thereby reducing the scale error in reading. Even more important than this would be the reduction of error due to zero shift and setting of the instrument which would be largely automatically compensated for by having the readings of similar magnitude.

It is along these lines that it is hoped to attain, in subsequent work, sufficient accuracy with an automatically recording instrument now under construction.

IV. THE METHOD FOR EVALUATING THE AMOUNT OF OZONE

Using four filters, measurements were made with two titanium photoelectric cells in July 1936, and with two other cells in July 1938. The transmissions in percent for the different filters, are plotted as a function of the solar air mass at the time of the observations.

In order to obtain a measure of the amount of ozone at the time of the observations, two methods have been employed. By the first method a solar energy curve outside the atmosphere is assumed. For this, observational data obtained by Pettit (**6**) is used (see fig. 9). Starting with this spectral energy curve, and by a process of integration (using 20 angstroms as a unit) a set of transmission curves for three of the filters having total transmissions of approximately 15, 40, and 60 percent for one of the photoelectric cells, as a function of solar air mass has been calculated. For these calculations the Fabry and Buisson (**7**) transmission coefficients for ozone and the Rayleigh scattering (atmospheric transmission) coefficients as used by O'Brien (**8**) in the reduction of the stratosphere balloon data (Explorer I and II) have been used. Some of the ozone and scattering transmission curves which were employed are reproduced in figure 4.

While this method gives values which are roughly in agreement with those obtained as described below, the calculated values indicate less ozone for the noon observations and more for the morning and afternoon (high air mass) measurements (see fig. 5). Hence the Pettit curve does not appear to be sufficiently accurate for this purpose, in that it is too low in value for the shorter wavelengths. The authors have therefore by the second method, similar to that employed by Stair and Coblentz in their stratosphere work, (**2**) set up a solar energy curve—not outside the atmosphere but within the range of air masses covered by the observations. First, by a method previously used by Coblentz and Stair (**3**) an approximate solar energy curve is set up for an air mass near the noon hour (low air mass), and adjusted until the calculated integral transmissions of the filters are in agreement with the observed values for some particular low air mass. Then, having a spectral solar energy curve which gives calculated transmissions for a photoelectric cell (No. 2 in this case) in agreement with the observations for one air mass, m= 1.06, for example (see fig. 5), calculations are made for transmissions at other air masses covering the air mass range of observations, for different amounts of ozone. This gives a diverging set of curves (A, B, and C, in fig. 5)

[5] Incidentally the device makes an excellent instrument around the laboratory for measuring extremely high resistances (low leakages) and small capacitances.

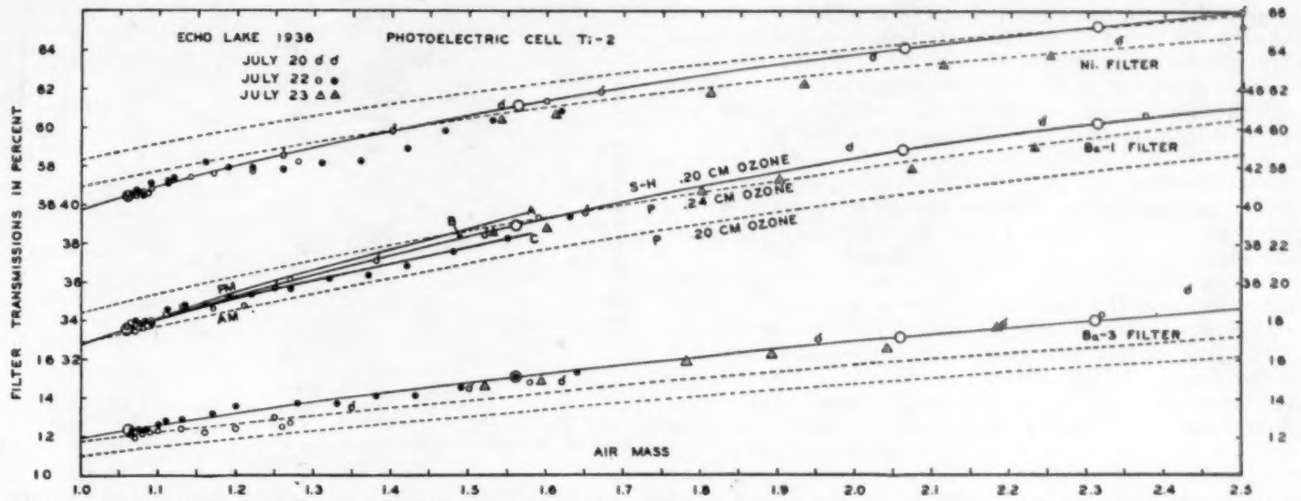


FIGURE 5.—Graphs showing the amount of ozone in the stratosphere, based on observations with titanium photoelectric cell No. 2; P, calculations based on the Pettit curve for air mass, m=0; S-H, calculations based on Stair-Hand solar energy curve, m=0, as determined from the observations for the two mornings, July 20 and 22, 1936.

through the value for air mass 1.06. The curve best representative of the observed data defines the amount of ozone above the observer at the time. In this case curve B for 0.20 cm. of ozone represents the data for the two mornings July 20 and 22. Curve C might have been chosen and the data for the afternoon of July 22 employed, yet this would be a bad choice since there are definite indications that the ozone value was changing.

The method is best presented by giving an example. Table 1 illustrates the calculations and method for obtaining one point (at air mass 1.56, see fig. 5) in one of the diverging curves for each of the three filters (Ni, Ba–1, Ba–3) through the point for air mass 1.06 referred to in the above example for titanium cell No. 2. In this table, column 1 gives the center of the wave-length interval and column 2 the relative spectral energy values found previously to give calculated transmissions of the filters which agree with the observed values for air mass 1.06. In column 3 are given transmission values for air mass 0.5 when scattering only is taken into account, since this calculation is to apply to air mass 1.56 and the starting values are already incorporated for m=1.06. Similarly transmission values for 0.10 cm. ozone—the ozone content of air mass 0.5—are used (given in column 4) because in the present illustration the diverging curve for 0.20 cm. of ozone is being calculated.

The product of columns 2, 3, and 4 gives column 5 which represents, therefore, a solar energy curve for air mass 1.56 and 0.20 cm. ozone. In column 6 the relative spectral response values (for equal energy) for photoelectric cell No. 2 are tabulated. The product (column 7) of columns 5 and 6 gives, consequently, the calculated integral response of the photoelectric cell for solar radiation, air mass 1.56, ozone value 0.20 cm. Columns 8, 10, and

TABLE 1.—*Illustrating the method employed in the calculation of ozone values*

Center of wave-length interval A	Relative energy M = 1.06	Scattering transmission M = 0.5	Transmission 0.10 cm. ozone	Columns 2 × 3 × 4 relative energy M=1.56	Relative response Ti-2	Columns 5 × 6 integrated response	Transmission Ni	Columns 7 × 8 integrated response	Transmission Ba-1	Columns 7 × 10 integrated response	Transmission Ba-3	Columns 7 × 12 integrated response
1	2	3	4	5	6	7	8	9	10	11	12	13
2900		0.646	0.010		0.76		0.014					
2920		.653	.033		.76		.039					
2940		.660	.077		.75		.070					
2960	0.3	.667	.140	0.03	.73	0.02	.100					
2980	.9	.674	.240	.15	.70	.10	.132	0.01				
3,000	1.75	.681	.325	.39	.66	.26	.165	.04				
3,020	2.6	.688	.415	.74	.62	.46	.204	.09	0.003			
3,040	3.55	.694	.500	1.23	.58	.71	.246	.18	.017	0.01		
3,060	4.65	.700	.580	1.89	.53	1.00	.293	.29	.035	.04		
3,080	6.2	.707	.660	2.89	.49	1.42	.343	.49	.060	.09		
3,100	7.2	.713	.725	3.72	.45	1.67	.398	.67	.090	.15		
3,120	8.6	.719	.780	4.82	.405	1.95	.457	.89	.133	.26	0.001	
3,140	10.1	.725	.825	6.04	.36	2.17	.514	1.12	.180	.39	.008	0.02
3,160	11.3	.731	.865	7.14	.32	2.29	.563	1.29	.237	.54	.023	.05
3,180	13.5	.737	.900	8.96	.285	2.55	.605	1.54	.310	.79	.042	.11
3,200	16.5	.744	.925	11.36	.245	2.78	.645	1.79	.380	1.06	.075	.21
3,220	21.2	.750	.943	14.99	.210	3.15	.680	2.14	.455	1.43	.127	.40
3,240	26.0	.756	.955	18.77	.175	3.29	.710	2.33	.526	1.73	.190	.62
3,260	30.2	.762	.966	22.23	.14	3.11	.737	2.29	.58	1.80	.25	.78
3,280	34.4	.768	.974	25.74	.105	2.70	.757	2.05	.63	1.70	.315	.85
3,300	38.9	.773	.982	29.53	.075	2.21	.775	1.72	.67	1.48	.38	.84
3,320	42	.779	.986	32.25	.045	1.42	.792	1.12	.703	1.00	.44	.62
3,340	45	.784	.989	34.9	.023	.80	.805	.65	.736	.59	.505	.41
3,360	48	.790	.993	37.6	.010	.38	.818	.31	.766	.29	.555	.21
3,380	50	.796	.997	39.7	.003	.12	.829	.10	.79	.09	.60	.07
Total						34.56		21.11		13.44		5.19
Percentage transmission								61.1		38.9		15.0

12 give the spectral transmissions of the three filters and columns 9, 11, and 13 the integrated photoelectric response through the three filters respectively. From the sums of the integrated values for the photoelectric cell alone and through the several filters the calculated filter percentage transmissions are obtained directly as ratios—e. g. 21.11÷34.56=61.1 percent. In this particular case the three values are 61.1, 38.9, and 15.0 percent and are plotted as large circles in figure 5 at air mass 1.56. Other points on the same curves and on other curves for differing amounts of ozone are similarly calculated.

Having determined the amount of ozone for a particular day, and using the solar energy curve in agreement with the observed data for one air mass (m=1.06 for the data of fig. 5), it is a simple matter, by a calculation which is the reverse of that illustrated in table 1, to calculate the relative solar energy curve for sunlight outside the atmosphere; and then from it transmission values for other amounts of ozone, other than the value in agreement with the data for that particular day, or days. This gives a set of nearly parallel curves (see figs. 6, 7, and 8), from which may be read the amount of ozone corresponding to any observed filter transmission when plotted as a function of

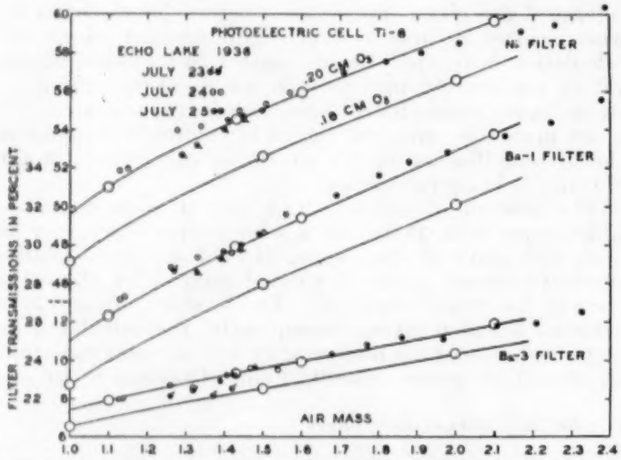


FIGURE 6.—Graphs showing the amount of ozone in the stratosphere, based on the observations with titanium photoelectric cell No. 6.

air mass. Although the preliminary calibrations and calculations for a particular photoelectric cell and set of filters are quite complicated, when these are once made it is simple from this set of curves to determine the ozone value from measurements with a single filter within a few minutes time. This is a highly important factor should such measurements become useful for forecasting purposes.

V. AMOUNT OF OZONE OVER MOUNT EVANS

In figures 5, 6, 7, and 8 are represented the observed data and the calculated amounts of ozone above Mount Evans as determined with the four photoelectric cells for the days on which measurements were obtained. While the data show much irregularity, which may in part be credited to instrumental difficulty, there are certain variations especially on July 22, 1936 (see fig. 5) when the ozone value was quite constant at 0.20 cm. (normal temperature and pressure) from early morning until 2:00 p. m., when it suddenly decreased to about 0.18 cm., or slightly less by 3:00 p. m., and then increased again to about 0.19 cm. by 4:00 p. m. The upper air mass maps for this date indicate a change in air mass, presumably at about the time that the

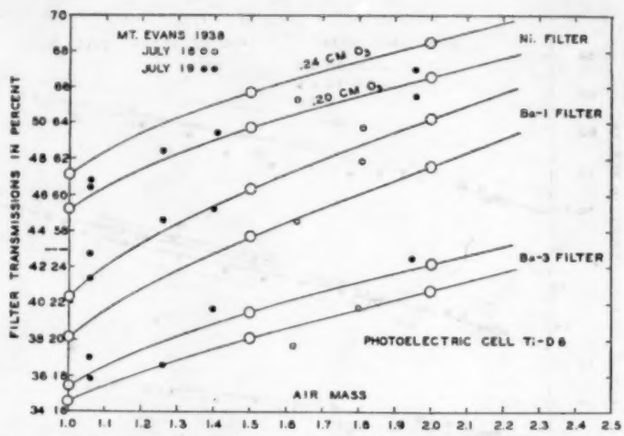


FIGURE 7.—Graphs showing the amount of ozone in the stratosphere, based on the observations with titanium photoelectric cell D-6.

ozone content changed.[6] On July 20 and July 23, 1936 our measurements and calculations indicate a fairly constant amount of ozone at about 0.20 cm. and 0.18 cm. respectively.

On July 23, 24, and 25, 1936, as measured with photoelectric cell No. 6 the value of ozone appeared to fluctuate around the 0.20 cm. value (see fig. 6) being possibly slightly lower on July 23, in agreement with data obtained earlier in the day with cell No. 2 (see fig. 5) and higher on July 24.

On July 16 and 19, 1938 (see fig. 7) the filter transmissions obtained by photoelectric cell D-6 indicate ozone in the amount of about 0.22 cm. normal temperature and pressure. July 19 was clear from early morning until noon. Two sets of measurements made near the noon

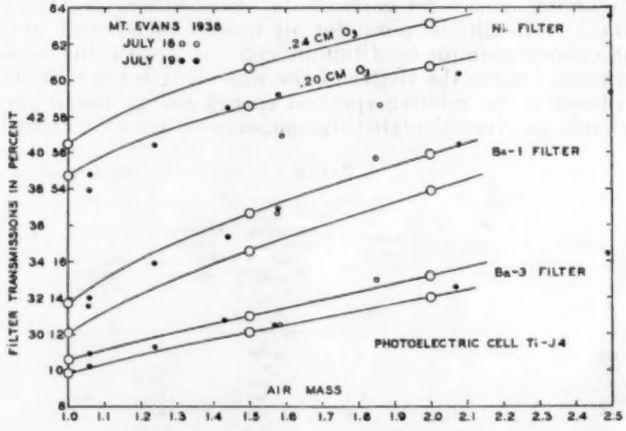


FIGURE 8.—Graphs showing the amount of ozone in the stratosphere, based on the observations with titanium photoelectric cell J-4.

hour, air mass 1.06, showed rapidly increasing transmissions for all the filters indicating an increase in ozone value of about 0.02 cm. within a period of less than an hour.

Alternate measurements were made on the same 2 days with cell J-4. The calculated amount of ozone based upon measurements with this cell was about 0.22 cm. in agreement with that for cell D-6 (see fig. 8). Considering the difficulties involved this agreement is remarkable, in view of the limited observations. Furthermore, the same increase of about 0.02 cm. ozone is to be noted in the noon measurements (air mass 1.06) with this cell.

[6] No correction has been made for possible temperature changes within the ozone layer

In connection with the change in ozone content on July 16 and 19, 1938, after inspection of the surface, upper air and isentropic charts, P. J. Harney of the Air Mass section of the Weather Bureau concludes:

On both July 16 and 19 surface cold fronts passed on the east slope of the mountains from the north and I would say there was a change of air mass at your station (Mount Evans) also. The following air was a few degrees cooler and had a 10 percent higher relative humidity on the Cheyenne APOB (airplane observation) at about 16,000 feet elevation on each day. However at your station we are not certain but that the air may have been in another air mass than that which was shown at Cheyenne with a change in it to be expected simultaneously with the change in the surface trough mentioned above. The upper winds indicate that the air arriving during July 16 came from the west and on the 19th from the northeast but both air masses were probably of Pacific origin.

To date the paucity of the available data prevents any definite conclusions as to the relation between changes in ozone content and change in type of air although in every case where the observations have shown a definite change in ozone content, there also has been an apparent change in the origin of the air.

VI. THE SOLAR ENERGY CURVE OUTSIDE THE ATMOSPHERE

It is to be noted that the relative solar energy curve outside the atmosphere [7] was calculated independently for each of the four cells. While the results obtained are not in exact agreement, the mean of the four determinations gives a relative energy curve which appears to be near the correct value in the spectral range 3,000 to 3,250 A. (see fig. 9).

By the same method as previously employed by Coblentz and Stair **(3)** for the reduction of their ultraviolet measurements to absolute value, for wavelengths 3,132 and shorter, we have evaluated our relative energy curve outside the atmosphere to yield absolute units, and for comparison this curve (average obtained for our four cells) is given along with an average for Petitt's data **(6)** at Mount Wilson and that of Coblentz and Stair **(11)** at Washington, D. C.

As may be seen from the figure our solar energy curve for m=0 is in close agreement with the others between 3,100 and 3,250 angstroms. Below 3,100 A. our curve indicates higher energy values in the form of a maximum at about 3,000 A. This is in agreement with some unpublished data of Brian O'Brien presented at a meeting of the Philosophical Society in Washington on May 20, 1939.

Incidently the curve calculated using the data obtained with photoelectric cell D–6 (fig. 9) coincides exactly with the average curve throughout the range 3000 to 3,250 A. in both shape and energy value. The calculated curves using cells Nos. 2 and 6 were in close agreement in general shape, but differed 5 to 20 percent in absolute energy values. This fact was unimportant in ozone calculations since only the shape of the curve, and not energy values, enter into the calculations. The calculations for cell J–4 differed most from the average. Energy values from 3,100 to 3,250 A. were in close agreement with those obtained with the other cells but below 3,100 A. a lower value was calculated. This is the least sensitive of the four cells and responds to a shorter spectral band. A small sensitivity to longer wave lengths not detected might account for this difference.

It is a distinct advantage to use several photoelectric cells with different spectral ranges to obtain more precise

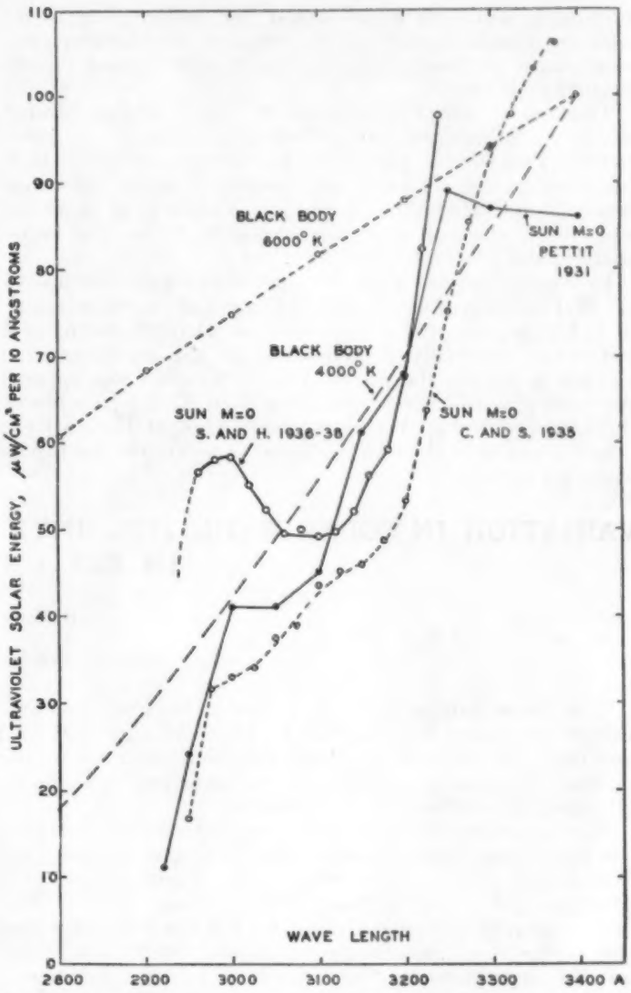


FIGURE 9.—Distribution of energy in the extreme ultraviolet of the solar spectrum. The S and H (Stair and Hand) curve is the average of the four determinations at Mount Evans with the four photoelectric cells. Curves by other observers and for a black body are given for comparative purposes.

values of the spectral solar energy curve. However, once the solar energy curve is accurately determined within the region of these short wavelengths future work will be greatly simplified and it will be more efficient to use only one, or at most two filters, having a total integrated transmission near 50 percent, since the transmission of a filter in that range is most sensitive to ozone changes when used with a photoelectric cell of the type employed in this work.

VII. CONCLUSIONS

While the data herein discussed are not extensive nor are the calibrations of the photoelectric cells in absolute agreement, the method promises an accurate measure of the ozone in the stratosphere. The preliminary calibrations and calculations for a particular photoelectric cell and set of filters is complicated, but when these are once made it should be possible, from a set of curves, to determine the ozone value from measurements with a single filter within a few minutes. This is a highly important factor should such measurements be used for forecasting purposes. In practice it may often be much more satisfactory to calibrate a complete new instrument

[7] The present and previous authors working in this field, are of course cognizant of the fact that the real spectral energy curve of solar radiation is not smooth but is indented by many absorption lines.

by comparison with a calibrated one rather than to go back to absolute units of microwatts, angstroms, etc., as we have purposely done in the present case for each photoelectric cell.

The values for the amount of ozone above Mount Evans as determined by the four cells are in close agreement. Two of the cells indicated a value of about 0.20 cm. normal temperature and pressure, while the other two cells indicated about 0.22 cm. This is in close agreement with that of other observers (**1, 9**) for the same latitude and season of the year.

In conclusion, we wish to express our appreciation to W. W. Coblentz of the National Bureau of Standards, and to J. C. Stearns of the University of Denver, for helpful assistance, especially in arranging for the work, and for making available the use of Mount Evans Observatory. We wish also to express our thanks to K. W. Kemper of the Lincoln, Nebr., Weather office, who, at his own expense, assisted in the observational program on the top of Mount Evans.

LITERATURE CITED

(1) Dobson, G. M. B. Proc. Roy. Soc. (London) (A) 129, 411 (1930).
(2) Stair, R. and Coblentz, W. W. J. Research N. B. S. 20, 185 (1938) R. P. 1075.
(3) Coblentz, W. W., and Stair, R. J. Research N. B. S. 16, 315 (1936) R. P. 877.
(4) Coblentz, W. W. and Stair, R. J. Research N. B. S. 12, 231 (1934) R. P. 647.
(5) Stair, R. J. Research N. B. S. 22, 295 (1939) R. P. 1181.
(6) Pettit, E. Astrophys. Jour. 75, 185 (1932); Pub. No. 445, Mount Wilson Observatory.
(7) Fabry, C. and Buisson, H. J. Phys. (5) 3, 196 (1913); Astrophys. J. 54, 297 (1921).
(8) O'Brien, B. J. Nat. Geog. Soc. Contrib. Tech. Papers, Stratosphere Series, No. 2, p. 49 (1936).
(9) Götz, F. W. P. Gerlands Beitr. Geophys. 31, 119 (1931).
(10) Forsythe, W. E. Letter of Nov. 24, 1931.
(11) Coblentz, W. W. and Stair, R. J. Research N. B. S. 17, 1 (1936) R. P. 899.
(12) Stair, R. and Hand, I. F. Preliminary Measurements of Ozone over Mount Evans, Colorado. Trans. of the American Geophysical Union for 1939.
(13) Coblentz, W. W. and Stair, R. J. Research N. B. S. 22, 573 (1939) R. P. 1207.

VARIATION IN SOLAR RADIATION INTENSITIES AT THE SURFACE OF THE EARTH IN THE UNITED STATES

By IRVING F. HAND

[Weather Bureau, Washington, D. C., May 1939]

This paper brings up to date two articles on the same subject published by Kimball in 1918 (**1**) and 1924 (**2**); however, the data here given are from stations in the United States only, whereas the previous papers included all available data for the entire globe.

The departures from normal were obtained by averaging the mean departures of each month's means for the three Weather Bureau radiation stations at Washington, D. C., Madison, Wis., and Lincoln, Nebr., and also for the Blue Hill station of Harvard University for the few years that this station has been in operation, and finally smoothing out the departures by the formula $(a+2b+c)/4$, where b is the average percentage departure for the month in question, and a and c are the average percentage departures for the preceding and following months, respectively. The smoothed percentages have been plotted in figure 1, and the same data tabulated in table 1.

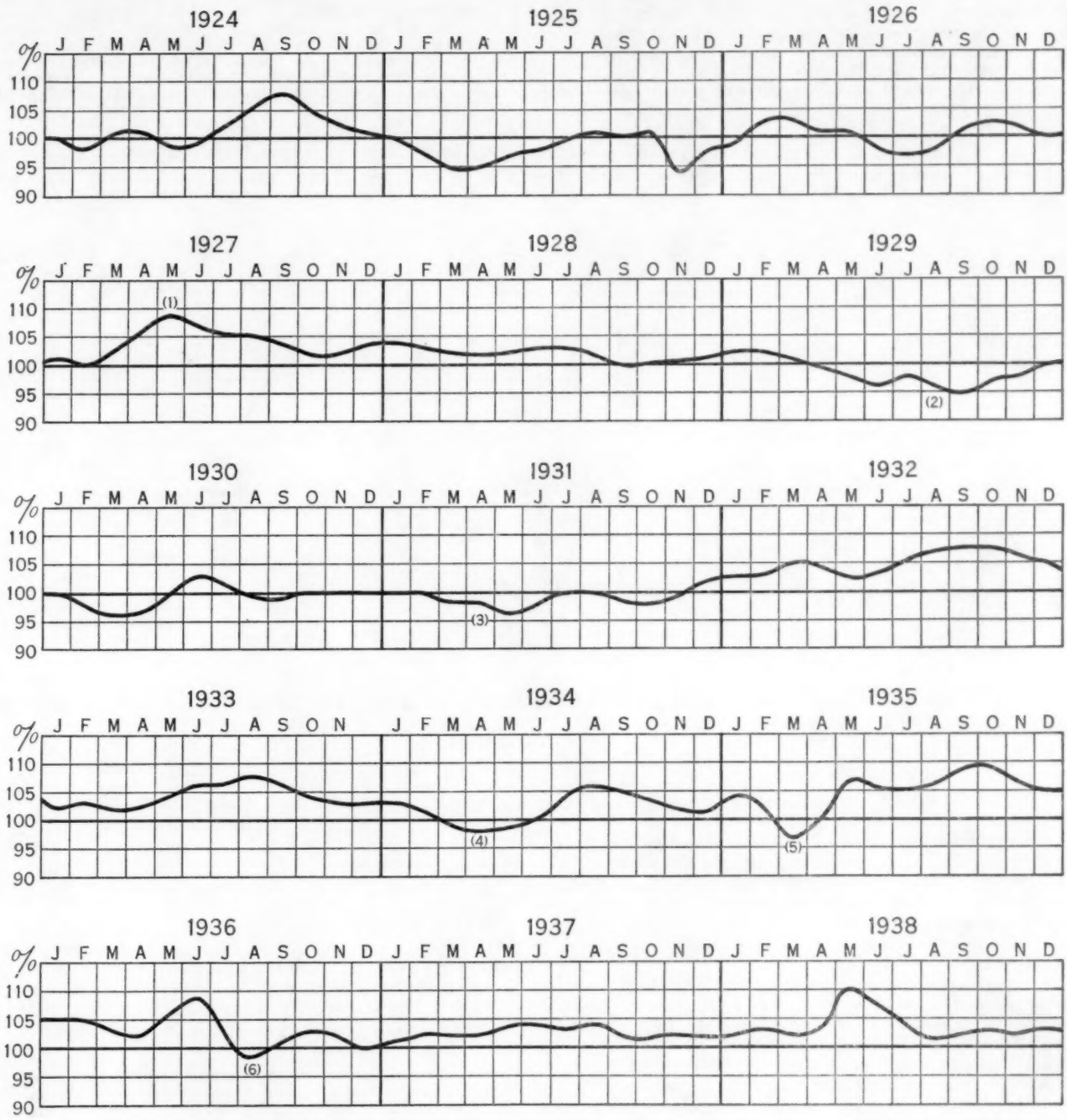
Owing to the small number of stations, local influences, such as duststorms, forest fires, irregular manufacturing activity, etc., are important factors in the fluctuations shown by the curve.

Although three major and several minor volcanic eruptions occurred during this 15-year period, no conclusive evidence appears that any of them depleted the solar energy received at the surface of the earth in the United States. The most violent explosive eruption during this period took place on the Isle Flores, Dutch East Indies, latitude 8° S. in August and September 1928, when an estimated 19½ million cubic meters of material were emitted. About the same amount of material was discharged from Quisapu volcano in Chile during its eruption in April 1929, but the proportion of lava-flow from this latter volcano was much greater than from the East Indies eruption. Although apparently neither eruption appreciably affected radiation receipt in the United States, it is interesting to note that the 1 or 2 months immediately following each explosion were those of minimum radiation receipt for the respective years. It is quite evident neither eruption carried large quantities of dust into the stratosphere; and in the case of the Chilean eruption we would expect very little dust to be transported across the equator from so southerly a latitude. The third violent eruption during the period occurred on the isle of Martinique in 1929 when Mount Pelée once again altered its skyline, this time without serious damage. That this eruption had little effect upon solar receipt is evident from the fact that solar radiation intensities began to increase immediately following the time of the volcanic activity.

As a matter of comparison with previous periods when volcanic activity did affect very appreciably solar radiation receipt at the earth's surface, we review briefly the effect of Krakatoa, Malay East Indies, latitude 7° S.; the explosion carried away the top of that mountain with such a detonation that it was heard for hundreds of miles, and with an emission of dust sufficient to deplete solar radiation receipt to but 84 percent of its normal. In 1902 the eruptions of Pelée on the island of Martinique, Santa Maria in Guatemala, and Colima in Mexico were followed almost immediately by an 18 percent diminution in intensity of radiation. The eruption of Katmai in Alaska on June 6, 1912, threw a tremendous amount of volcanic ash into the stratosphere which resulted in a decrease of 22 percent in radiation receipt, and a continuation of gradually lessening atmospheric contamination for 2 years.

In all three cases, owing to decreased solar heating of the earth, temperatures remained subnormal for at least a year following the individual explosions. With this in mind, attention may be drawn to the fact that temperatures in this country have been considerably above normal during the past 8 years, although this condition may have no relation to the increased radiation receipt.

The lack of volcanic eruptions of the type that throws dust into the stratosphere accounts for the general increase in radiation during the period 1924–38. It is far more difficult to explain why individual years show such a marked increase in radiation. However, there seems to



MONTHLY AVERAGES OF SOLAR RADIATION AT EARTH'S SURFACE, EXPRESSED AS PERCENTAGES OF THE MONTHLY NORMALS.

FIGURE 1.—Explanation of the reference numbers:
(1) Noon observations of May and June, 1927, were the highest ever recorded at Washington. (3)
(2) Forest fires. (4)
(3) Dust storms of unusual intensity. At Madison during the course of the observations on April 10, 1931, the radiation intensity at normal incidence was reduced from 1.20 gram calories at 9:30 a. m. with air mass 1.5, to 0.141 gram calories at 2:07 p. m. with air mass 1.45. (5)
(4) Dust storms also reduced intensities during 1934. At Lincoln, Nebr., radiation dropped to less than a quarter of a calorie. (6)
(5) Dust storms again depleted normal incidence radiation to such an extent that Madison reported the lowest total solar and sky record ever obtained during a single day. (7)
(6) Madison and Lincoln both reported considerable haze, dust and smoke. (8)

be little doubt that the large radiation receipt in 1932 was due in part, at least, to decreased manufacturing. In the January issue of the MONTHLY WEATHER REVIEW (60: 256) we find the following statement:

The outstanding feature for the year (1932) is the unprecedented large increase in radiation received on a horizontal surface from the sun at various places throughout the country. Without doubt the business depression was an important indirect factor in this increase. It will be noted that the large cities of New York and Chicago show the greatest plus departures. Dust and smoke records from these two cities show a marked diminution for the year, which would be expected as the amount of manufacturing had fallen off greatly during this period.

TABLE 1.—*Departures of normal incidence radiation in the United States*

Month	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
January	100	100	99	101	104	102	100	100	103	102	103	104	105	101	102
February	98	97	103	100	103	102	97	100	103	103	102	102	105	102	103
March	101	94	103	102	102	101	96	98	105	102	99	96	103	102	102
April	101	95	101	106	102	100	96	98	104	102	98	100	102	102	103
May	98	97	101	109	102	98	99	96	102	104	99	107	106	103	110
June	99	98	98	107	103	96	103	98	104	106	100	105	109	104	108
July	102	100	97	105	103	98	101	100	106	106	104	105	102	103	104
August	106	101	98	105	102	96	99	100	107	108	106	106	98	104	101
September	108	100	102	104	100	95	99	98	107.5	106	105	109	101	102	102
October	105	101	103	102	100	97	100	98	108	104	103	109	103	101	103
November	102	94	102	102	101	98	100	100	106	103	102	106	102	102	102
December	101	98	100	104	101	100	100	102	105	103	101	105	100	102	103
Year	+1.7	−2.1	+0.6	+3.9	−1.9	−1.4	−0.8	−1.0	+5.0	+4.1	+1.8	+4.5	+3.0	+2.3	+3.6

LITERATURE CITED

(1) Kimball, Herbert H. Volcanic eruptions and solar radiation intensities. MONTHLY WEATHER REVIEW, August 1918, 46: 355–356.

(2) Kimball, Herbert H. Variation in solar radiation intensities measured at the surface of the earth. MONTHLY WEATHER REVIEW, November 1924, 52: 527–529.

(3) Kimball, Herbert H. Solar and sky radiation measurements during May 1927. MONTHLY WEATHER REVIEW, May 1927, 55: 242.

(4) Kimball, Herbert H. Solar and sky radiation measurements during August 1929. MONTHLY WEATHER REVIEW, August 1929, 57: 345.

(5) Cameron, Donald C. Great dust storm in Washington and Oregon. MONTHLY WEATHER REVIEW, May 1931, 59: 195–199.

(6) Hand, Irving F. Solar and sky radiation measurements during April 1934. MONTHLY WEATHER REVIEW, April 1934, 62: 135.

See also

Mattice, W. A. Dust storms, November 1933 to May 1934. MONTHLY WEATHER REVIEW, February 1935, 63: 53–57.

(7) Hand, Irving F. Solar radiation measurements during March 1935. MONTHLY WEATHER REVIEW, March 1935, 63: 102.

(8) Hand, Irving F. Solar radiation measurements during August 1936. MONTHLY WEATHER REVIEW, August 1936, 64: 269.

TROPICAL DISTURBANCE OF SEPTEMBER 24–26, 1939, IN THE GULF OF MEXICO

By WILLIS E. HURD

[Weather Bureau, Washington, October 1939]

Only one tropical disturbance was reported during September. There was unsettled weather over the extreme northwestern part of the Caribbean Sea early on September 23. It is probable that this disturbed condition moved northwestward across the British Honduras and Yucatan during the 23d and early 24th under influence of a tropical disturbance that apparently developed about 100 miles east of Vera Cruz, Mexico, between September 20 and 22.

A report received by mail from the American steamer *Aztec* states that westerly winds of force 8 during squally weather were experienced from late on the 22d to early on the 24th in the southwestern part of the Gulf of Campeche and that there were heavy northwesterly swells.

At 7 p. m. (E. S. T.) of the 24th there was a fairly definite circulation, with slightly depressed barometer, near latitude 22° N., longitude 92° W., with winds of force 3–5 reported by ships within the area 20°–25° N., 90°–95° W.

During the 25th the central barometer had deepened somewhat and squally winds about the center showed local increases in force. At 7 a. m. of the 25th, in 26°05′ N., 91°45′ W., the Panamanian motorship *Cubahama* experienced a north-northeast gale of force 9, which is the highest wind velocity reported by a ship in connection with the depression. Her barometer, in a report later received by radio, was given as 1,005.8 millibars (29.70 inches). This reading, following the result of a later comparison at Mobile, was corrected to 1,003.7 millibars (29.64 inches), which is the lowest pressure reported for the disturbance.

On September 26, at 7 a. m. (E. S. T.), as the center was entering the coast, the American steamer *Roanoke*, at some distance to the southward, had a south-southwest wind of force 7, barometer 1,010.2 millibars (29.83 inches), in 27°56′ N., 89°00′ W. Quoting from the report of W. R. Stevens, forecaster on duty at the New Orleans office of the Weather Bureau:

> The disturbance moved inland south of New Orleans a short distance west of Grand Isle the morning of September 26, with only fresh winds near the center. A passing squall caused a southwest wind of 49 miles per hour at Pensacola, Fla., the morning of September 26 after the disturbance had moved inland.
>
> No report of damage or loss of life has been received.

Advisory warnings of the disturbance were issued by the Weather Bureau at New Orleans at frequent intervals from 9:30 a. m. (E. S. T.) of the 25th until 9:45 a. m. (E. S. T.) of the 26th. Chart XIII shows the path of the disturbance from the 24th to 26th, and the general situation on the morning of the 25th.

NOTES AND REVIEWS

Abstracts of literature on biometeorology.—The increasing interest in climatic and meteorological factors in their relation to biology, medicine, and agriculture is one of the significant trends of modern science. Ecologists have long appreciated the importance of temperature, humidity, radiation, barometric pressure, wind movement, and meteorological factors generally, as important factors in controlling the distribution and abundance of animals and plants. Foresters, horticulturists, and entomologists have likewise been concerned with the interrelationships of climatic and meteorological factors to the organisms with which they work. The developments of air conditioning and aviation have lately brought other important research groups into the field, resulting in an increasing amount of research. This is often the work of individuals and groups not now in effective contact with biologists, and frequently appears in periodicals not commonly consulted by biologists.

In all civilized nations diverse research groups have sprung into being which, though they often devote much attention to the same fundamental natural forces, still work in practical isolation from each other, with a different background of training, and associations, belonging to different societies meeting at different times and places, publishing in different journals, reading different literature, investigating different types of things. These groups, however, are beginning to apply common ideas and common methods to the study of situations that are basically similar. For example, techniques and concepts derived from a study of the influence of weather factors on the spread of influenza or the common cold are likely to have a very high transfer value as applied to the study of the spread or survival of plant disease or economic insects. Conversely, it should be possible for research workers in the field of public health to make use of many findings of the entomologists, foresters, ecologists, plant pathologists, and other biological groups.

Abstracting journals are admirably suited to the sort of synthesis of fundamental knowledge that this situation demands; and the journal *Biological Abstracts* has recently undertaken a more complete abstracting and segregation of the current research literature in bioclimatology and biometeorology, for the use of workers in medicine, public health, ecology, agriculture, forestry, botany or zoology, geography, and other fields. The section *Bioclimatology-Biometeorology* will appear within the section "Ecology" in *Biological Abstracts*, and will be under the editorship of Robert G. Stone of the Blue Hill Observatory, Harvard University.

Under the sectional publication plan this material will be found, at present, not only in section A, *Abstracts of General Biology*, but also under section B, *Abstracts of Experimental Animal Biology*, section D, *Abstracts of Plant Sciences*, and section E, *Abstracts of Animal Sciences*.

BIBLIOGRAPHY

By AMY P. LESHER

[RICHMOND T. ZOCH, *in Charge of Library*]

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Albright, Joseph Clarence.
Summer weather data with design data, statistics, charts, maps, and technical analysis; compiled and edited by J. C. Albright. 1st ed. [Kansas City, Kans.] The Marley company, 1939. xv, 165 p. incl. illus. (maps), tables, diagrs. 28½ x 22½ cm.

American forestry association.
Flood control; papers presented at the sixty-second annual meeting of the American forestry association. Cincinnati & Zanesville, Ohio, May 31–June 3, 1937. [Washington, D. C., 1937.] 80 p. 23 cm.

[Brooks, Donald Bane.]
Psychrometric charts for high and low pressures (from ⅛ to 10 atmospheres). New York. [n. d.] 2 p. tables. 30½ cm. (H. & V.'s reference data, 65-66.)

Cannegieter, H. G.
25 jaar aerologie in Nederland. [Leiden. 1936] p. 824–832. 25 cm. (Overgedrukt uit het tijdschrift van het Koninklijk Nederl. aardrijkskundig genootschap. 2e serie deel LIII, 1936, Aflevering 6.)

De Fina, Armando L.
Las exigencias meterorológicas de los vegetales. Buenos Aires. 1938. p. 187–193. 27½ cm. (De la Revista de la Facultad de agronomía de La Plata (tercera época) tome xxi (1936).)

Hobeniche, P.
Étude aérologique de la région de Conakry. Paris. 1937. 9 p. plates, tables, diag. (fold.) 25½ cm. (Extrait du Bulletin du Comité d'études historiques et scientifiques de l'Afrique occidentale française. Tome xix, nos. 2-3, avril–septembre 1936.)

Nor sur la climatologie de la côte de Guinée. Paris. 1935. 6 p. tables. 23 cm. (At head of title: Ministère des colonies. Institut national d'agronomie de la France d'Outre-mer.) (Extrait de l'Agronomie coloniale, bulletin mensuel de l'Institut national d'agronomie de la France d'Outre-mer, no. 209, Mai 1935.)

Notes sur divers phénomènes météorologiques en Guinée française. Paris. 1937. 6 p. maps (fold.) 25½ cm. (Extrait du Bulletin du Comité d'études historiques et scientifiques de l'Afrique occidentale française, tome xix, nos. 2–3, avril–septembre 1936.)

Hull, Hezekiah.
Appendix. Weather chart January 1, 1837–December 15, 1837, Berlin, N. Y. Taken from the diary of Hezekiah Hull. [Berlin, N. Y. 1837.] 8 p. 28½ cm. [Typewritten.]

Jurva, Risto.
Atlas der Eisverhältnisse des Baltischen Meeres an den Küsten Finnlands. Helsingfors. 1937. 51 p. 41 cm.

Klappich, Heinz.
Die Oberflächenfeuchte der menschlichen Haut und ihre meteorophysiologischen Beziehungen. Berlin. 1938. p. 363–386. tables, diagrs. 23 cm. (Sonderdruck. Zeitschrift für die gesamte experimentelle Medizin. 103. Band, 3. Heft.)

Loew, Adolphus.
Causes of the great natural catastrophes in the U. S. A. Message to his Excellency the President of the United States for the representatives of astronomic science, submitted by Adolphus Loew. Modern theories, explanations, and computations of the glacial period, of the orbit of the earth, of the orbit of the moon. [Reinbach-Basel, 1938.] [23] p. plates. 29½ cm. Various pagings. Mimeographed.

Lord, Russell.
To hold this soil. [Washington, D. C. 1938.] 122 p. front., plates. 26 cm. (U. S. Dept. of agriculture. Miscellaneous publication no. 321.) Contribution from Soil conservation service. "Recommended reading": p. [123].

Mitra, S. K., & Rakshit, H.
Distribution of the constituent gases and their pressures in the upper atmosphere. Calcutta. 1938. p. 47–61. tables. 26 cm. (Reprinted from Indian journal of physics, v. 12, pt. 1. March 1938.)

Ontario. Hydro-electric power commission. Electric engineering department. Distribution section.
Coincident glaze and wind loading of pole lines. [Toronto?] 1937. 6 p. 11 pl. 27½ cm.

Philippines (Commonwealth). Weather bureau.
Typhoons originating in the China sea, by Rev. Charles E. Deppermann, S. J., assistant director, Weather bureau. Manila. 1938. 51 p. incl. illus. (map, charts), tables. 29 cm. At head of title: Commonwealth of the Philippines. Department of agriculture and commerce. Weather bureau. Manila central observatory. "References": p. [21].

Puig, Ignacio.
Actualidades cientificas. 1ª. serie de artículos publicados en el diario católico argentino "El Pueblo." [Tomo 1. Buenos Aires.] 1938, 200 p. illus. 20 cm. (At head of title: Biblioteca científica del Observatorio de física cósmica de San Miguel.)

Red Cross. U. S. American national Red cross.
The Ohio-Mississippi valley flood disaster of 1937. Report of relief operations of the American Red cross. Washington, D. C. [1938.] 252 p. front. (fold. map), illus., diagrs. 23 cm. (A. R. C. [circular] 977.) Foreword signed: Norman H. Davis, chairman. Bibliography: p. 248.

Rhumbler, L.
Windfahnen mit Auf- und Abwind-Anzeiger. p. 387–402. (*In* Mitteilungen aus Forstwirtschaft und Forstwissenschaft . . . 1935, VI. Jahrgang- Heft 4.)

Rivault, R.
Un nouveau mode d'investigation de l'ionosphère. [Paris. 1937.] 2 p. illus. 28 cm. (Extrait de la Revue générale de l'électricité. Oct. 2, 1937. t. xlii, p. 435–436.)

Rossby, Carl-Gustaf, & others.
Fluid mechanics applied to the study of atmospheric circulations. (Research conducted in cooperation with U. S. Department of agriculture under Bankhead-Jones special research fund.) Part I. A study of flow patterns with the aid of isentropic analysis. A: On the maintenance of the westerlies south of the polar front, by Carl-Gustaf Rossby. B: Technique and examples of isentropic analysis, by Jerome Namias. C: Isentropic analysis of a case of anticyclogenesis, by Ritchie G. Simmers. Cambridge & Woods Hole, Mass. 1938. 125 p. illus., maps, tables, diagrs. 28 cm. (Massachusetts institute of technology and Woods Hole oceanographic institution. Papers in physical oceanography and meteorology. v. 7, no. 1. December, 1938.)

Rouch, M. J.
Le climat de la Méditerranée. [Paris. n. d.] 282 p. maps. 27 cm. (Commission internationale pour l'exploration scientifique de la Mer Méditerranée. Rapports et procès-verbaux des reunions. v. 11. (nouvelle série) Météorologie. premier rapport).)

Rymill, John, & others.
Southern lights; the official account of the British Graham land expedition, 1934–1937. With 2 chapters by A. Stephenson, and an historical introduction by Hugh Robert Mill. London. 1938. xv, 295 p. front., illus., plates, ports., maps (part fold.) 26 cm.

Schafmayer, A. J., & Grant, B. E.
Rainfall intensities and frequencies. New York. 1938. p. 344–401. tables, diagrs. 23 cm. (American society of civil engineers. Paper no. 1989. Reprinted from "Transactions," v. 103.)

Spaeth, J. N., & Diebold, C. H.
Some interrelationships between soil characteristics, water tables, soil temperature, and snow cover in the forest and adjacent open areas in south-central New York. Ithaca. 1938. 76 p. illus., tables, diagrs. 23 cm. (Cornell university, Agricultural experiment station. Memoir 213. June 1938.)

Troxel, S. M.
A relative humidity nomograph. [New York.] 1937. p. 350. diagram, 30½ cm. (From Review of scientific instruments. September, 1937. v. 8.)

U. S. Board of surveys and maps.
Map collections in the District of Columbia. Compiled by the Map information office, January 1930. Printed in cooperation with the National resources committee. [Washington, D. C.] 1938. 7, 50 p. 26½ cm. At head of title: Prepared by the Geological survey for the Federal board of surveys and maps, Washington. Title-page printed, text mimeographed.

U. S. Chief signal officer.
Charts issued by the Signal corps. Washington, D. C. 1935. 14 p. 23 cm. (Circular no. 8–10.) [Mimeographed.]
Preparation of meteorological radio messages. 2 p. (Bound with above publication.)

U. S. Soil conservation service. Division of research.
Precipitation on the Muskingum river watershed, Ohio by 30-minute periods. January–February, 1938. [New Philadelphia, Ohio. 1938.] 2 v. maps. 21 x 35 cm. (Muskingum climatic research center, New Philadelphia, Ohio; Soil conservation service, U. S. Department of agriculture; Muskingum watershed conservancy district; Works progress administration.) [Processed.]

U. S. Special advisory committee on hydrologic data.
Proposals for projects in hydrologic research. Section V, Evaporation. [Washington, D. C.? 1937.] 24 p. 27 cm. [Mimeographed.]

U. S. Weather bureau.
Abbreviations authorized for use in meteorological transmissions by radio and teletype. Effective October 1, 1934. [Washington, D. C. 1934.] 1 card. 35½ cm.
Auroral data obtained during Second international polar year, August 1932–August 1933. [Washington, D. C. n. d.] 3 vols. plates, tables, diagrs. 27½ cm. [Photostated.]
Average conditions of wind and weather, North Pacific ocean. Compiled for the information of ocean travelers from data in the Marine division of the Weather bureau, by Willis Edwin Hurd. Issued September 1937. Washington, D. C. 1937. 12 p. map. 23 cm. At head of title: United States Department of agriculture. Weather bureau.
Instructions for six-hourly airway service, beginning January 15, 1937. Washington, D. C. 1936. 29 p. 27 cm. [Mimeographed.]

U. S. Works progress administration. Division of social research.
The people of the drought states. Prepared by Conrad Taeuber and Carl C. Taylor. Washington, D. C. 1937. 81 p. maps, tables. 25½ cm. (Research bulletin, Series 5, no. 2.) [Processed.]

Begard, Lars.
Results of investigations of the auroral spectrum during the years 1921–26. With 25 text figures and 4 plates. [Oslo. 1932.] 71 p. illus., plates, diagrs. 31 cm. (Geofysiske publikasjoner. vol. ix, no. 11.) "Papers concerning the auroral spectrum previously published by the author": p. 71.

Villagrasa, Manuel Rodriguez.
[Cloud forms.] Madrid. [n. d.] 10 hand drawn charts. 23½ cm.

Visher, Stephen S.
Rainfall-intensity contrasts in Indiana, causes and consequences. [New York. 1938.] p. 627–637. maps. 26 cm. (Reprinted from The geographical review, v. 28, no. 4, October, 1938.)

Walter, Heinrich.
Die Periodizität von Trocken- und Regenjahren in Deutsch-Südwestafrika auf Grund von Jahresringmessungen an Bäumen. Berlin. 1937. p. 608–620. illus. 24½ cm. (Sonderabdruck aus den Berichten der Deutschen botanischen Gesellschaft, Jahrgang 1936, Band LIV, Heft 10.)

Ward, Robert de Courcy.
The thunderstorms of the United States as climatic phenomena. Washington. 1917. 18 p. maps, diagrs. 23 cm.

Whipple, F. J. W.
The propagation of sound to great distances. London. 1935. p. 285–308. 3 plates, illus. 24½ cm. (Reprint from the Quarterly journal of the Royal meteorological society. v. 61, no. 261. July, 1935.)

Whitfield, Charles J.
Sand dunes of recent origin in the southern Great Plains. (U. S. Department of agriculture. Journal of agricultural research. v. 56, no. 12, June 15, 1938, p. 907–917. illus. 23 cm. Washington, D. C. 1938.) (Contribution from Soil conservation service (S–1). Published June 28, 1938.) "Literature cited": p. 917.)

Wiechert, Erwin.
Untersuchungen an Baystörungen unter besonderer Berücksichtigung der Störmerschen Theorie. Inaugural-Dissertation. Würzburg. 1934. 26 p. illus., tables. 30 cm.

Woelfle, Max.
Sturmschäden in Wald. Berlin. 1936–37. v. p. illus. 25½ cm. (Sonderabdruck. Forstwissenschaftliches Centralblatt. 58. Jahrgang, Heft 18, 15. September 1936; 59. Jahrgang, Heft 3, 1. Februar 1937; 59. Jahrgang, Heft 18, 15. September 1937.)

Wolken über Land und Meer. Taunus & Leipzig. [1937?] 48 photos. 21 cm.

Wundt, Walter.
Das Bild des Wasserkreislaufs auf Grund früherer und neuer Forschungen. Berlin. 1938. 79 p. diagrs. 21 cm. (Mitteilungen des Reichsverbandes der Deutschen Wasserwirtschaft E. D., Deutscher Wasserwirtschafts- und Wasserkraft-Verband. 1938. Nr. 44.)

SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, SEPTEMBER 1939

By CHARLES M. LENNAHAN

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at 10 cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory at Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptons of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 8 a. m. (75th meridian time) and at noon (local mean solar time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Direct radiation intensities averaged above normal for September at Lincoln and slightly below normal at Madison and Blue Hill.

Total solar and sky radiation during September was above normal at all stations except Fresno, La Jolla, Miami, and Riverside.

TABLE 1.—*Solar radiation intensities during September 1939*

WASHINGTON, D. C.

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance: 8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Sept. 5	14.60				1.03						10.21
Sept. 18	5.79				1.34						5.79
Sept. 23	10.97				.88						11.81
Sept. 25	13.13				.90						12.68
Means					**1.04**						
Departure					**−.01**						

[1] Extrapolated.

TABLE 1.—*Solar radiation intensities during September 1939*—Con.

MADISON, WIS.

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance: 8 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Sept. 5	8.81	0.86	0.94	1.10	1.26	1.42					8.81
Sept. 12	11.81	.47	.58	.74	.95	1.11					15.65
Sept. 14	15.11	.70	.80	.94	1.13	1.25	1.01				15.65
Sept. 15	15.11	.53	.61	.77	.95	1.13					13.61
Sept. 19	7.87	.71	.84	1.01	1.16	1.33	1.10				7.29
Sept. 20	9.83					1.42	1.31	0.75			6.50
Sept. 21	6.50		1.03	1.14	1.24	1.40	1.25	1.04			6.02
Sept. 22	6.02	.60	.74	.91							6.02
Sept. 27	5.79			.68	1.08	1.30	1.24	.95			7.87
Sept. 28	7.87	.61	.70	.80	.91	1.02	.80				10.21
Sept. 30	4.17		.45	.53							4.95
Means		**.64**	**.74**	**.86**	**1.08**	**1.26**	**1.12**	**.91**			
Departures		**−.14**	**−.14**	**−.14**	**−.07**	**−.13**	**−.06**	**−.11**			

LINCOLN, NEBR.

Sept. 5	8.48				1.00						9.83
Sept. 7	10.97						1.02	0.76	0.57	0.35	10.97
Sept. 8	9.47	0.44	0.54	0.67			1.00	.78	.61	.49	12.08
Sept. 9	8.18	.88	.98	1.13	1.32						8.48
Sept. 12	11.38						1.16	.96	.78	.62	11.81
Sept. 13	13.61	.83	.94	1.06	1.24				.62	.49	13.13
Sept. 14	11.81	.87	.97	1.09	1.26		1.15	.92	.78	.68	11.38
Sept. 15	[2] 6.68	.78	.90	[2] .05	1.23						11.38
Sept. 16	10.98	.84	.93	1.05							5.56
Sept. 18	5.56	.85	.95	1.09	1.27		1.26	1.06	.92	.78	7.04
Sept. 19	5.56	.76	.86				1.09				9.14
Sept. 20	6.02				1.34		1.35	1.17	1.03	.91	4.57
Sept. 21	3.63	.82	.93	1.08	1.24		1.25	1.07	.89	.79	4.57
Sept. 22	4.75	.89	1.00	1.14	1.32		1.21	.97	.82	.70	4.95
Sept. 26	4.75						1.19	.98	.82		4.75
Sept. 27	3.90				1.30		1.22	1.03	.85	.73	6.02
Sept. 28	7.04	.69	.82	.96	1.18						7.57
Sept. 29	4.37				1.28		1.35	1.18	1.06	.92	3.99
Sept. 30	3.30				1.30						4.17
Means		**.79**	**.89**	**1.03**	**1.25**		**1.19**	**.99**	**.81**	**.68**	
Departures		**+.05**	**+.05**	**+.06**	**+.11**		**+.03**	**+.01**	**−.02**	**−.04**	

BLUE HILL, MASS.

Sept. 1	11.5						0.82	0.55	0.42	0.33	11.5
Sept. 2	14.7		0.28	0.41	0.56	0.77	.61	.44	.33	.15	16.4
Sept. 4	14.7				.75		.75	.58	.45		15.3
Sept. 6	7.6	0.94	1.02	1.10	1.26	1.40	1.24				6.3
Sept. 7	7.6					1.40	1.22	1.02	.88	.78	5.6
Sept. 9	9.2	.81	.94	1.05	1.18	1.33	[1] 1.05	.94	.82	.75	9.2
Sept. 11	8.8	.86	.96	1.07	1.22	1.36	1.22	1.06	.92	.82	8.8
Sept. 13	8.2					1.47					8.6
Sept. 14	10.3					1.49	1.18	1.02			9.2
Sept. 15	11.9				.85	1.13					13.7
Sept. 16	13.7				.83	1.05	.88	.67	.52	.44	17.5
Sept. 18	5.6					1.40	1.22	1.06	.92	.81	5.2
Sept. 19	6.5		1.00	1.12	1.25	1.47	1.28	1.10	.99	.90	6.5
Sept. 22	6.3	.92	1.01	1.11	1.24	1.36	1.16	1.01	.86	.75	5.4
Sept. 23	10.3				1.08	1.20					8.8
Sept. 24	8.8			.64	.85					.35	9.6
Sept. 28	9.2								.72	.63	10.3
Means		**.88**	**.87**	**.93**	**1.01**	**1.29**	**1.05**	**.86**	**.71**	**.61**	
Departures		**+.05**	**−.07**	**−.11**	**−.13**	**−.07**	**−.07**	**−.08**	**−.10**	**−.08**	

LATE REPORT

BLUE HILL, MASS.

Aug. 2	9.9					1.32	1.12	0.78			10.3
Aug. 3	12.8						.78	.60	0.48	0.39	14.3
Aug. 5	15.8						1.13	.93	.79	.50	10.3
Aug. 6	9.6							.91			9.2
Aug. 7	11.9									.37	14.3
Aug. 11	13.2			0.92	1.06		1.04	.88	.74	.60	6.1
Aug. 12	14.7			.86	1.03	1.21	1.12	.95	.83	.75	12.8
Aug. 14	16.9							.84	.68		13.2
Aug. 16	16.9				.68						16.4
Aug. 17	14.7		0.50	.58	.70						16.9
Aug. 23	13.2	0.62	.68	.77	.96	1.29	.95	.70	.52	.42	13.2
Aug. 24	12.8	.46	.58	.72	.89						13.7
Aug. 27	12.3								.64	.54	12.8
Aug. 28	11.1	.71	.80	.90							11.5
Means		**.60**	**.64**	**.79**	**.89**	**1.27**	**1.02**	**.82**	**.67**	**.51**	
Departures		**−.09**	**−.21**	**−.14**	**−.17**	**−.01**	**−.05**	**−.09**	**−.04**	**−.09**	

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Cambridge	Fairbanks	La Jolla	Miami	Riverside	Blue Hill	San Juan	Friday Harbor	Newport
	Gram-calories per square centimeter														
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Sept. 3	543	454	527	422	311	592	405	212	384	378	349	403	579	472	456
Sept. 10	467	441	511	449	392	503	435	160	405	415	381	456	623	373	476
Sept. 17	446	428	457	457	377	483	410	218	444	431	360	452	587	393	438
Sept. 24	325	289	418	280	215	375	235	133	346	382	340	262	627	321	240
	Departures of daily totals from normals														
Sept. 3	+156	+79	+69	+75	−18	+16	.....	+15	−83	−47	−131	+13	+8	+46	+11
Sept. 10	+98	+100	+78	+138	+73	−34	.....	−45	−76	−41	−71	+83	+48	−4	+64
Sept. 17	+81	+80	+29	+126	+76	−10	.....	+54	+40	−36	−54	+91	+29	+68	+79
Sept. 24	−22	−7	+38	+5	−65	−77	.....	+3	−10	+27	−60	−72	+91	+10	−89
	Accumulated departures since Jan. 1.														
	+16,415	+10,500	+6,643	+16,660	+6,144	+252	.....	+784	+3,143	−4,214	−5,157	+2,961	+8,391	+6,188	+2,597

LATE REPORTS

Station	Week beginning— July 30	Aug. 6	Aug. 13	Aug. 20	Aug. 27	Accumulated departures since Jan. 1
Twin Falls	Average daily total	534	597	569	469	[1] 489	+994
	Departure from normal	−16	+43	+66	−57	+3	
La Jolla	Average daily total	509	480	468	452	571	+4,046
	Departure from normal	−35	−36	−3	−61	+92	
Friday Harbor	Average daily total	674	601	621	516	370	+5,348
	Departure from normal	+105	+57	+81	+17	−57	

Station	Week beginning— July 2	July 9	July 16	July 23	Accumulated departures since Jan. 1
Twin Falls	Average daily total	574	591	688	580	+721
	Departure from normal	−21	−9	+73	+11	

[1] 6-day mean.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.) Superintendent, U. S. Naval Observatory. Data from measurements at the U. S. Naval Observatory from plates obtained at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's visible hemisphere. For each day, below longitude, latitude, area of spot or groups, and spot count, are given respectively the assumed longitude of the center of the disk, assumed latitude of the center of the disk, tota larea of spots and groups, and total spot count]

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°					
Sept. 1	11 23	6592	−88	251	−18	87	242	2	VG	U. S. Naval.
		6591	−66	273	+4	65	121	2		
		(*)	−58	281	−11	62	12	3		
		6587	−26	313	−9	25	73	6		
		(*)	−23	316	−4	25	24	4		
		6586	−2	337	−8	16	194	8		
		6586	+5	344	−8	17	291	39		
		6585	+9	348	−15	24	1,939	63		
		6588	+20	359	+27	27	48	5		
		6590	+58	37	−5	60	12	2		
				(389)	(+7)		2,956	134		
Sept. 2	11 27	6592	−72	254	−18	76	339	2	G	Do.
		6591	−52	274	+4	52	97	1		
		6594	−40	286	+30	45	36	4		
		6587	−13	313	−9	20	36	2		
		(*)	+7	333	−18	24	24	4		
		6586	+11	337	−8	18	194	10		
		6586	+17	343	−8	23	291	30		
		6585	+22	348	−15	30	1,939	65		
		6588	+31	357	+28	36	97	11		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°					
Sept. 2		6588	+35	1	+24	38	24	2		
		6593	+36	2	+6	36	61	7		
		(*)	+55	21	−15	60	6	2		
				(326)	(+7)		3,144	140		
Sept. 3	12 14	6592	−58	254	−18	62	388	2	G	U. S. Naval.
		6591	−38	274	+4	38	73	3		
		6587	−1	311	−9	16	36	2		
		6586	+27	339	−8	32	145	7		
		6586	+32	344	−8	36	194	21		
		6585	+35	347	−15	41	1,891	50		
		6586	+36	348	−7	39	48	2		
		6588	+41	353	+29	45	97	10		
		6588	+46	358	+27	50	97	10		
		6588	+50	2	+25	52	12	3		
		6593	+50	2	+6	50	6	2		
				(312)	(+7)		2,987	112		
Sept. 4	11 4	6598	−80	220	−15	81	533	12	VG	Do.
		6598	−78	222	−12	80	436	7		
		6598	−70	230	−16	72	194	3		
		6597	−60	240	+19	61	145	13		
		6592	−45	255	−18	51	388	6		
		6596	−40	260	+12	41	12	3		
		6591	−25	275	+4	25	73	3		
		6587	+11	311	−9	19	36	6		
		6595	+25	325	+14	26	48	7		
		6586	+43	343	−8	45	339	31		
		6586	+49	349	−7	50	48	2		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°					
Sept. 4...	11 4	6585	+49	349	−15	52	1,891	55		
		6588	+57	357	+27	10	145	18		
				(300)	(+7)		4,288	166		
Sept. 5...	11 2	6599	−73	214	+18	72	12	1	VG	U. S. Naval.
		6598	−70	217	−17	74	1,224	21		
		6598	−65	222	−12	68	436	14		
		6598	−65	222	−15	69	291	13		
		6598	−56	231	−16	60	291	8		
		6597	−47	240	+19	48	291	39		
		6592	−31	256	−18	40	315	6		
		6591	−11	276	+3	12	73	6		
		6587	+25	312	−10	30	36	9		
		6595	+43	330	+13	40	24	7		
		6586	+55	342	−8	58	436	32		
		6586	+61	348	−6	63	48	1		
		6585	+62	349	−15	64	2,182	45		
		6588	+68	355	+28	69	36	6		
				(287)	(+7)		5,095	208		
Sept. 6...	11 18	6601	−80	193	−8	81	12	2	F	Do.
		6600	−78	195	−19	80	242	1		
		6599	−60	213	+18	60	24	2		
		6598	−57	216	−17	61	970	20		
		6598	−48	225	−14	52	1,164	20		
		6598	−42	231	−17	47	412	4		
		6597	−33	240	+19	33	218	13		
		6592	−18	255	−18	31	291	2		
		6591	+2	275	+4	3	61	1		
		6586	+68	341	−7	69	145	1		
		6586	+73	346	−8	74	485	7		
		6585	+78	351	−15	80	2,182	18		
				(273)	(+7)		6,206	91		
Sept. 7...	10 57	6603	−75	185	−19	79	6	1	F	Do.
		6601	−69	191	−7	70	61	2		
		6600	−64	196	−19	69	242	1		
		6598	−44	216	−17	50	921	38		
		6598	−37	223	−14	43	970	47		
		6598	−30	230	−17	38	412	10		
		6597	−20	240	+19	23	364	38		
		6592	−5	255	−18	24	291	6		
		6591	+15	275	+4	15	48	3		
		6602	+38	298	−15	43	36	7		
		6586	+83	343	−8	85	145	5		
		6585	+87	347	−14	88	970	7		
				(260)	(+7)		4,466	165		
Sept. 8...	10 55	6603	−61	186	−19	65	145	8	VG	Do.
		6601	−54	193	−7	55	36	2		
		6600	−49	198	−19	54	218	3		
		6598	−31	216	−18	39	776	43		
		6598	−28	224	−12	29	679	38		
		6598	−21	236	−16	31	582	38		
		6598	−17	230	−17	28	412	4		
		6597	−10	237	+21	17	24	4		
		6597	−6	241	+19	13	291	16		
		6592	+9	256	−18	26	291	3		
		(*)	+17	264	+11	17	6	1		
		(*)	+20	267	+5	20	6	1		
		6591	+29	276	+4	29	36	2		
		6602	+54	301	−16	57	48	2		
				(247)	(+7)		3,550	165		
Sept. 9...	10 56	6607	−74	160	−6	75	170	1	F	Do.
		6606	−61	173	−6	63	24	1		
		6603	−49	185	−18	54	267	4		
		6601	−41	193	−7	43	24	1		
		6600	−36	198	−19	43	194	3		
		6605	−29	205	+17	31	97	10		
		6598	−17	217	−17	27	630	21		
		6598	−10	224	−12	20	582	24		
		6598	−8	226	−11	19	679	35		
		6598	−3	231	−18	25	412	5		
		6597	+5	239	+21	14	97	9		
		6597	+8	242	+19	15	194	11		
		6592	+21	255	−18	32	218	3		
		6604	+22	256	−17	30	24	4		
		6602	+69	303	−16	70	36	1		
				(234)	(+7)		3,648	133		
Sept. 10...	12 6	6608	−65	155	−20	70	24	4	F	Do.
		6607	−60	160	−7	63	145	1		
		6606	−48	172	−7	51	24	3		
		6603	−35	185	−19	43	218	9		
		6600	−22	198	−19	33	194	2		
		6598	+3	223	−12	18	582	30		
		6598	+5	225	−17	23	388	17		
		6598	+5	225	−16	22	679	35		
		6598	+11	231	−17	26	412	5		
		6597	+20	240	+20	24	194	17		
		6592	+36	256	−18	42	194	3		
		6604	+38	258	−17	43	24	3		
		6591	+56	276	+4	55	6	1		
				(220)	(+7)		3,084	130		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°					
Sept. 11...	10 50	6609	−88	119	+12	88	291	4	VG	U. S. Naval.
		(*)	−59	148	−11	62	6	1		
		6608	−56	151	−21	61	97	10		
		6607	−48	159	−7	50	194	2		
		6606	−35	172	−7	37	85	16		
		6603	−25	182	−19	35	73	1		
		6603	−19	188	−18	31	194	8		
		(*)	−16	191	−8	21	36	3		
		6600	−10	197	−19	27	194	10		
		6598	+7	214	−17	24	97	15		
		6598	+10	217	−15	25	2,182	70		
		6598	+22	229	−17	31	485	6		
		6597	+33	240	+21	35	73	4		
		6597	+34	241	+18	36	36	3		
		6592	+49	256	−19	55	218	3		
		6604	+53	260	−16	57	24	1		
				(207)	(+7)		4,285	157		
Sept. 12...	12 0	6609	−73	121	+13	73	218	10	G	Do.
		6608	−43	151	−21	50	145	19		
		6607	−34	160	−7	37	170	3		
		6606	−21	173	−6	26	73	8		
		6603	−8	186	−19	25	194	14		
		6600	+6	200	−19	26	170	3		
		6598	+20	214	−18	31	121	11		
		6598	+30	224	−15	37	2,085	60		
		6598	+37	231	−18	45	485	6		
		6597	+47	241	+21	48	36	1		
		6592	+62	256	−18	66	242	2		
				(194)	(+7)		3,939	137		
Sept. 14...	12 12	6609	−45	122	+12	46	97	9	F	Do.
		6608	−14	153	−20	30	291	30		
		6607	−8	159	−7	16	194	2		
		6606	+9	176	−7	17	73	7		
		6603	+22	189	−18	32	97	10		
		6600	+31	198	−18	39	194	1		
		6598	+47	214	−18	53	121	10		
		6598	+56	223	−15	60	1,939	55		
		6598	+61	228	−18	66	630	4		
		6597	+71	238	+21	71	36	1		
				(167)	(+7)		3,672	129		
Sept. 15...	11 3	6612	−85	70	−21	88	97	1	F	Do.
		6611	−49	106	−16	34	12	1		
		6610	−32	123	+16	33	48	3		
		6609	−31	124	+13	31	36	2		
		(*)	−24	131	+7	24	12	4		
		6608	−2	153	−19	16	194	19		
		6607	+5	160	−6	13	194	1		
		6603	+35	190	−19	43	36	3		
		6600	+45	200	−19	51	170	3		
		6598	+60	215	−18	64	291	11		
		6598	+69	224	−15	70	1,939	37		
		6598	+75	230	−18	79	630	4		
				(155)	(+7)		3,659	89		
Sept. 16...	10 53	6612	−75	67	−21	76	242	6	F	Do.
		6612	−69	73	−21	71	194	10		
		6611	−38	104	−16	45	48	4		
		(*)	−28	114	+15	30	24	9		
		6610	−19	123	+15	21	36	5		
		6609	−18	124	+13	20	48	3		
		6608	+10	152	−20	27	194	26		
		6607	+19	161	−7	23	194	1		
		6603	+30	192	−19	56	12	2		
		6600	+59	201	−19	62	194	1		
		6598	+73	215	−18	76	291	5		
		6598	+85	227	−15	87	679	12		
				(142)	(+7)		2,156	84		
Sept. 17...	11 37	6614	−87	41	−7	86	291	4	VG	Do.
		6612	−65	63	−22	68	339	17		
		6612	−56	72	−21	61	679	27		
		6611	−25	103	−17	34	36	2		
		6613	−13	115	+18	17	36	3		
		6613	−11	117	+17	16	48	5		
		6609	−5	123	+13	9	48	8		
		6608	+25	153	−20	36	145	16		
		6607	+33	161	−7	36	194	1		
		(*)	+52	180	−8	54	36	2		
		6603	+63	191	−19	66	12	2		
		6600	+72	200	−19	75	194	1		
				(128)	(+7)		2,058	90		
Sept. 18...	11 12	6614	−73	42	−7	73	485	7	VG	Do.
		6615	−69	46	+12	68	12	1		
		6612	−45	70	−22	52	873	59		
		6611	−11	104	−17	26	12	5		
		6613	0	115	+18	12	73	9		
		6613	+2	117	+18	13	48	7		
		6609	+7	122	+13	10	48	5		
		6608	+39	154	−21	47	36	6		
		6607	+46	161	−7	47	194	2		
				(115)	(+7)		1,781	101		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°					
Sept. 19	13 36	6617	−75	25	+6	74	48	2	G	U. S. Naval.
		6614	−59	41	−7	60	485	17		
		6615	−52	48	+12	51	24	1		
		6612	−31	69	−21	42	776	39		
		6613	+15	115	+18	20	48	5		
		6613	+18	118	+16	21	73	2		
		6609	+21	121	+13	22	12	5		
		6608	+53	153	−21	57	12	3		
		6607	+60	160	−7	62	194	1		
				(100)	(+7)		1,672	75		
Sept. 20	10 59	6617	−60	29	+7	59	73	7	G	Mount Wilson.
		6614	−49	40	−7	51	48	26		
		6615	−40	49	+13	40	36	3		
		6612	−21	68	−20	34	291	30		
		6612	−13	76	−21	30	388	16		
		(*)	−12	77	+18	16	24	1		
		6613	+31	120	+17	33	48	3		
		6609	+36	125	+13	36	12	1		
		6607	+72	161	−7	74	194	4		
				(89)	(+7)		1,114	91		
Sept. 21	10 50	6618	−88	348	−13	85	970	4	G	U. S. Naval.
		6617	−50	26	+7	50	73	7		
		6617	−45	31	+7	44	97	2		
		6614	−37	39	−7	39	73	9		
		6614	−31	45	−7	34	291	16		
		6615	−26	50	+12	26	24	1		
		6612	−9	67	−22	29	242	27		
		6612	0	76	−21	27	339	12		
		(*)	0	76	+13	6	12	2		
		6613	+43	119	+17	42	97	5		
		6609	+46	122	+13	45	12	1		
		6607	+88	164	−7	86	194	3		
				(76)	(+7)		2,424	89		
Sept. 22	11 5	6618	−74	348	−13	75	1,357	20	G	Do.
		6619	−70	352	−8	71	73	7		
		6617	−38	24	+8	38	97	10		
		6617	−32	30	+7	32	48	10		
		6614	−22	40	−7	25	24	2		
		6614	−19	43	−7	24	436	42		
		6615	−12	50	+12	12	12	3		
		6612	+3	65	−22	29	97	14		
		6612	+12	74	−21	29	242	11		
		6613	+57	119	+17	57	73	1		
				(62)	(+7)		2,459	120		
Sept. 23	10 50	6619	−60	349	−7	62	388	53	VG	Do.
		6618	−58	351	−13	60	1,939	30		
		6619	−49	0	−7	57	36	5		
		6617	−23	26	+7	22	97	15		
		6617	−20	29	+7	21	48	10		
		6614	−4	45	−7	13	485	35		
		6612	+17	66	−21	33	73	9		
		6612	+25	74	−21	36	218	15		
		6613	+70	119	+15	69	48	4		
				(49)	(+7)		3,332	176		
Sept. 24	11 44	6621	−86	309	+14	82	582	3	G	Do.
		6619	−45	350	−7	47	485	45		
		6618	−45	350	−13	49	1,600	18		
		(*)	−39	356	−18	46	61	1		
		6619	−36	359	−7	37	36	5		
		6617	−10	25	+7	10	36	6		
		6617	−5	30	+6	4	24	3		
		6614	+10	45	−7	16	485	25		
		6612	+31	66	−21	42	48	4		
		6612	+40	75	−21	48	218	13		
				(35)	(+7)		3,575	123		
Sept. 25	10 59	6621	−72	311	+14	71	630	4	VG	Do.
		(*)	−60	323	−13	63	6	1		
		6618	−31	352	−13	37	1,454	30		
		6619	−31	352	−7	34	485	45		
		(*)	−26	357	−18	35	61	8		
		6619	−23	0	−7	26	36	5		
		6617	+6	29	+8	6	48	4		
		6617	+8	31	+6	7	12	1		
		6614	+24	47	−8	27	436	19		
		6612	+53	76	−21	57	242	4		
				(33)	(+7)		3,410	121		
Sept. 26	10 57	6622	−77	293	+16	75	242	4	VG	Do.
		6621	−59	311	+14	57	727	16		
		6618	−18	352	−13	26	1,454	28		
		6619	−17	353	−7	22	436	42		
		(*)	−13	357	−17	25	48	2		
		(*)	+15	25	+22	20	24	1		
		6617	+21	31	+7	21	12	1		
		(*)	+30	40	−5	33	85	7		
		6614	+38	48	−7	41	242	10		
		6612	+68	78	−21	72	145	3		
				(10)	(+7)		3,415	114		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No. NNNN	Heliographic: Difference in longitude	Heliographic: Longitude NNN	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count NNN	Plate quality	Observatory
1939	h m		°		°					
Sept. 27	12 30	6623	−86	269	+19	83	194	2	F	Mount Wilson.
		6622	−62	293	+14	60	291	12		
		6621	−45	310	+14	43	533	8		
		6620	−27	328	+19	31	194	14		
		6618	−4	351	−13	20	1,406	30		
		6619	−3	352	−8	15	388	35		
		6617	+33	28	+8	32	48	4		
		6614	+41	36	−7	46	73	10		
		6614	+51	46	−7	55	121	6		
		6612	+83	78	−20	85	145	1		
				(355)	(+7)		3,393	122		
Sept. 28	13 12	6625	−80	262	−16	82	242	2	G	U. S. Naval.
		6623	−73	269	+19	71	388	6		
		6622	−49	293	+16	49	388	20		
		6621	−31	311	+15	32	509	20		
		6620	−13	329	+18	16	339	17		
		6624	−9	333	+12	10	12	4		
		6619	+9	351	−7	16	339	48		
		6618	+9	351	−13	21	1,357	30		
		6618	+17	359	−17	30	48	3		
		6617	+48	30	+7	48	61	12		
		6614	+66	48	−5	67	145	12		
				(342)	(+7)		3,828	174		
Sept. 29	13 37	6625	−72	256	−15	74	145	6	VG	Do.
		6625	−63	265	−13	64	194	10		
		6627	−62	266	+12	61	36	2		
		6623	−57	271	+20	59	533	20		
		6622	−33	295	+15	33	242	50		
		6621	−17	311	+15	17	412	14		
		6620	0	328	+17	10	97	13		
		6626	+1	329	−9	15	24	5		
		6624	+5	333	+13	9	824	1		
		6619	+21	349	−7	25	170	60		
		6618	+22	350	−14	30	1,067	65		
		*	+63	31	+6	62	36	4		
		6614	+77	45	−6	77	121	7		
				(328)	(+7)		3,901	257		
Sept. 30	12 7	*	−81	235	−13	82	145	3	VG	Do.
		6623	−62	254	+22	62	61	9		
		6625	−60	256	−15	63	73	6		
		6627	−51	265	+12	51	97	10		
		6625	−50	266	−13	54	218	6		
		6623	−46	270	+21	46	679	30		
		6622	−28	288	+16	27	145	15		
		6622	−20	296	+16	23	388	30		
		6621	−4	312	+14	8	485	6		
		6628	−3	313	−18	25	48	5		
		6620	+12	328	+18	17	109	15		
		6626	+15	331	−8	21	97	19		
		6624	+16	332	+13	16	121	28		
		6619	+32	348	−7	35	194	53		
		6618	+35	351	−15	40	970	50		
				(316)	(+7)		3,830	285		

Mean daily area for 29 days = 3,377.

*=not numbered. F=fair; G=good; VG=very good.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR SEPTEMBER 1939

[Dependent alone on observations at Zurich]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich Switzerland]

September 1939	Relative numbers	September 1939	Relative numbers	September 1939	Relative numbers
1	*ab* 103	11	*Ec* 136	21	*ad* 89
2	*s* 116	12	*a* ---	22	88
3	124	13	127	23	*a* 88
4	*Ecd* 119	14	92	24	*d* 107
5	---	15	*a* ---	25	106
6	*d* 136	16	*d* ---	26	*d* 98
7	114	17	---	27	*Ecbd* 105
8	*Eac* 145	18	*d* 67	28	*d* 131
9	*abd* 159	19	88	29	*a* 131
10	*b* 168	20	70	30	*Mc* 137

Mean, 25 days 113.8.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: *E*, on the eastern part of the sun's disk; *W*, on the western part; *M*, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in charge]

By B. FRANCIS DASHIELL

During September radiosonde observations were inaugurated in the United States proper at Buffalo, N. Y.; Minneapolis, Minn.; St. Louis, Mo.; Medford, Oreg.; Billings, Mont.; and Spokane, Wash. The airplane flights at the two latter stations were discontinued with the termination of August and replaced by radiosonde observations. Upper-air reports made during the hurricane season at Swan Island, in the western Caribbean Sea, are included for the first time. Airplane observations taken at 8 United States naval stations are shown in table 1, while the radiosonde data from 24 stations are given in table 1a. Tables 2 and 3 contain upper-air wind directions and velocities, and table 4 gives the heights of the tropopauses. Charts VIII, IX, X, and XI, show the mean pressures, temperatures, and resultant winds at 1.5, 3, 4, and 5 kilometers, respectively, and chart XII gives the September isentropic data. A detailed description of the above charts and tables will be found in the January 1939 MONTHLY WEATHER REVIEW.

An area of mean low barometric pressure extended north and northeast of the United States at 5,000 feet (chart VIII), while mean high pressure prevailed over the Southeast. However, a falling pressure tendency again appeared south of this high-pressure area, being indicated by the observations made at Swan Island. At 3, 4, and 5 kilometers (charts IX, X, and XI) the lowest mean pressures occurred over Sault Ste. Marie, Mich., and the highest over Pensacola, Fla. But above 5 kilometers, at all levels given in table 1a, mean pressure was high over the Southwest, and also from southern Florida to Puerto Rico. The lowest pressure existed along the northern border of the country, and falling pressure southward over the western Caribbean. The pressure gradient, or difference between the mean pressures recorded over the low and high areas in the North and South, respectively, at each level from the surface to the maximum altitude reached, shows that this gradient difference increased steadily with altitude to 14 millibars at 10 kilometers. Above that altitude the gradient difference steadily decreased from 14 millibars to 2 millibars at 19 kilometers.

Mean relative humidity at 1.5 kilometers was high over the Northeast and Southeast and low over the western half of the country. The humidity at 3 kilometers was high over the Great Lakes and Florida, and low over the middle Atlantic coast and California, and moderately low west of the Mississippi. At 4 kilometers humidity was highest over Florida and moderately high over the Rocky Mountains and Great Lakes region while the lowest humidity occurred over the Pacific coast. Similar conditions prevailed at 5 kilometers. However, there was some increase over the Rocky Mountains and a decrease over the middle Atlantic and Pacific coasts. At all levels above 5 kilometers humidity was low over the Pacific coast and the central portion of the United States, while high humidities prevailed along the northern border, over Florida, and thence southwestward over the Caribbean.

Mean free-air temperatures were seasonally lower in September than during the preceding month. In all cases below-zero temperatures occurred beneath the 5-kilometer level, while slightly north of the 40th parallel similar temperatures existed under 4 kilometers. At all levels, from the surface up to 5 kilometers, where observations are made both by airplanes and radiosonde, mean temperatures were lowest over Sault Ste. Marie, Mich. Highest temperatures were noted over Phoenix, Ariz., up to 1 kilometer; over El Paso, Tex., up to 3 kilometers; over San Diego, Calif., at 4 kilometers; and over Miami, Fla., at 5 kilometers.

Above 5 kilometers, where all observations are made by radiosonde, lowest temperatures occurred over Spokane, Wash., up to 11 kilometers; Buffalo, N. Y., at 12 and 13 kilometers; Charleston, S. C., at 14 and 15 kilometers; and El Paso, Tex., at 16, 17, and 18 kilometers. Highest mean temperatures occurred over Phoenix, Ariz., Albuquerque, N. Mex., El Paso, Tex., and Miami, Fla., at 6, 7, 8, 9, and 10 kilometers; over Phoenix, Ariz., at 11, 12, and 13 kilometers; and Spokane, Wash., from 14 to 18 kilometers. Stations which were warmest in the lower levels became coldest in the upper levels, and vice versa. Above 13 kilometers the mean temperatures at Swan Island became colder than those recorded elsewhere, while the temperatures over San Juan, P. R., above 16 kilometers, were nearly as low as those recorded over Swan Island, but colder than elsewhere.

Of all the 704 radiosonde flights made during September at the 24 stations listed in table 1a, 99, 95, 87, 41, and 11 percent reached altitudes of 5, 10, 15, 20, and 22 kilometers, respectively. At most stations individual flights reached 22 and 23 kilometers, and one radiosonde ascension over Nashville, Tenn., rose to 28 kilometers, a height equalled but once before, at Miami, Fla., during the preceding month. The lowest individual temperatures reported from the upper air occurred over Swan Island (−80.8° C.) at 17 kilometers, and in the United States proper over Albuquerque, N. Mex. (−77.2° C.) at 18 kilometers, and Charleston, S. C. (−77.0° C.) at 16 kilometers. Individual temperatures over the more northern stations were not so low, such as that of −64.2° C. over Spokane, Wash., and −67.4° C. over Minneapolis, Minn., both at 16 kilometers.

During the month the lowest minimum mean temperatures were recorded in the South over Swan Island (−75.8° C.), San Juan, P. R. (−72.9° C.), El Paso, Tex. (−72.6° C.), Albuquerque, N. Mex. (−72.0° C.), Charleston, S. C. (−71.0° C.), and Miami, Fla. (−70.3° C.). The highest minimum mean temperatures were noted in the North over Spokane, Wash. (−59.5° C.), Minneapolis, Minn. (−61.4° C.), Sault Ste. Marie, Mich. (−61.5° C.), Bismarck, N. Dak. (−61.8° C.), and Billings, Mont. (−62.3° C.).

September pilot-balloon observations were made at 97 Weather Bureau stations in the United States proper, and the resultant wind directions and forces based on these flights as well as others made in Canada, Mexico, and Cuba, are shown on charts VIII, IX, X, and XI, for 1.5, 3, 4, and 5 kilometers, respectively. During the month 79 percent of these stations reached a maximum altitude of 10 kilometers; 17 percent exceeded 15 kilometers; and 5 percent ascended to 20 kilometers or more. High altitudes were reached at Tampa, Fla., Las Vegas, Nev., Redding, Calif., Wichita, Kans., Omaha, Nebr., Denver, Colo., and San Juan, P. R., particularly on the 15th, 16th, 17th, and 18th, east of the Mississippi and north of the Ohio, and in the Rocky Mountain region.

At 1.5 kilometers (chart VIII) the resultant wind directions for the current month, based on 5 a. m., 75th

meridian time observations, showed a well defined anticyclonic circulation around a cell of high pressure over Alabama. At its center (Birmingham, Ala.) a rare occurrence of a resultant calm was noted. Very light resultant velocities occurred over Atlanta, Ga., Jacksonville, Fla., Spartanburg, S. C., and Jackson, Miss. Light velocities also existed over the middle Pacific coast. Southeasterly winds over Cuba, Mexico, and the Gulf States became southwesterly over the South Central States and westerly and northwesterly over the Northern and Eastern States. Southerly winds prevailed over the far West. Resultant velocities were unusually low over the Southeast, but were moderately high over the Central, Northern, and Northeastern States.

The anticyclonic circulation over the Southeast at 1.5 kilometers continued at 3 kilometers (chart IX) and maintained its same central position over Alabama. At 3 kilometers the easterly winds over the Gulf area turned clockwise so that southerly and southwesterly directions over the far Southwest became westerly and northwesterly over the northern and northeastern portions of the country. Resultant velocities at 3 kilometers remained low over the Southeast and high over the northern half of the United States, becoming outstanding at Havre, Mont. (9.6 m. p. s.), Kylertown, Pa. (9.9 m. p. s.), and Burlington, Vt. (10.6 m. p. s.).

A continuation of the anticyclonic circulation at 1.5 and 3 kilometers was indicated at 4 kilometers (chart X). These observations were made at 5 p. m., 75th meridian time. At this altitude the high-pressure cell tilted toward the west so as to be centered approximately over Jackson, Miss. Wind directions elsewhere were mostly southwesterly, becoming northwesterly in the north and northeastern States. High resultant velocities occurred over all sections except in the South and Southeast, being highest over Detroit, Mich. (13.5 m. p. s.) and Minneapolis, Minn. (13.2 m. p. s.).

Resultant wind directions at 5 kilometers (chart XI) showed the center of the southern cell to be over extreme eastern Texas. The anticyclonic circulation over the South still was pronounced at this altitude. Southwesterly winds prevailed generally over the Southwest and southern Pacific coast, while westerly and northwesterly winds were general over the northern and eastern portions of the country. Resultant velocities were rather high over the entire northern half of the United States, with extremes centered over the north-Central States (Minneapolis, Minn., 15.0 m. p. s., and Fargo, N. Dak., 14.5 m. p. s.). Velocities throughout the South, with the exception of southern Florida and southern California, were unusually low.

The current resultant-wind directions at 24 well-distributed stations showed they departed from the normal direction at 1.5 kilometers by assuming counterclockwise rotations. This was true for all of the country except the extreme Southeast and the far Northwest. There the current winds were oriented by clockwise rotations from normal directions. Outstanding departure differences between the current and normal directions, were noted at Medford, Oreg. (69° counterclockwise), Oakland, Calif. (160° clockwise), Seattle, Wash. (47° clockwise), and Atlanta, Ga. (43° clockwise). At 1.5 kilometers resultant velocities were less than normal over the Pacific coast as well as in the East, but elsewhere velocities were greater than normal. Moderate velocity departures occurred over Billings, Mont., San Diego, Calif., Oklahoma City, Okla., and Washington, D. C.

At 3 kilometers the September wind directions were oriented from normal by turning in counterclockwise rotations over all but the eastern portion of the country. Large differences in departure occurred over Nashville, Tenn. (147° clockwise), Atlanta, Ga., Oklahoma City, Okla., Cheyenne, Wyo., Seattle, Wash., and Oakland, Calif. (86°, 64°, 36°, 46°, and 47°, respectively—all counterclockwise). Velocities at the 3-kilometer level were greater than normal over the sections of the country where directions departed by counterclockwise rotations. Elsewhere the velocities were less than normal. Large resultant-velocity departures from normal were noted over Omaha, Nebr. (+2.9 m. p. s.), Houston, Tex. (+3.6 m. p. s.), Boston, Mass. (−4.0 m. p. s.), Washington, D. C. (−3.1 m. p. s.) and Detroit, Mich. (−2.4 m. p. s.).

Table 2 gives resultant winds based on observations made at 5 p. m. (E. S. T.). Southwesterly winds in the lower levels turned gradually with altitude until they became northwesterly in the upper levels over Buffalo, N. Y., Cincinnati, Ohio, Fargo, N. Dak., Huron, S. Dak., Minneapolis, Minn., Oklahoma City, Okla., Omaha, Nebr., Nashville, Tenn., St. Louis, Mo., Spokane, Wash., and Washington, D. C. However, at Medford, Oreg., and Boise, Idaho, northwesterly winds at the surface backed gradually through the higher levels to become southwesterly.

Comparing these 5 p. m. observations with 5 a. m. normals for all levels up to 5 kilometers at 20 selected stations, it was noted that the current afternoon directions departed from normal by small counterclockwise rotations. At Nashville, Tenn., and Atlanta, Ga., the current departures from normal at all levels were by large clockwise rotations, and outstanding departures having counterclockwise rotations from normal were noted over Oklahoma City, Okla., Houston, Tex., and Albuquerque. N. Mex. Current velocities at Omaha, Nebr., Oklahoma City, Okla., Billings, Mont., Houston, Tex,, and Cincinnati, Ohio, were considerably greater than normal.

When the 5 a. m. winds at 1.5 and 3 kilometers (charts VIII and IX) were compared with the 5 p. m. winds for the same levels (table 2) it was noted that definite diurnal changes of direction occurred. At 1.5 kilometers the September 5 p. m. resultant-wind directions differed from the 5 a. m. directions by departing from the latter in counterclockwise rotations over most of the country, except the middle Atlantic coast, far Southwest, and southern California, where the 5 p. m. diurnal changes were by clockwise rotations. At 3 kilometers the 5 p. m. winds differed from those at 5 a. m. by showing counterclockwise diurnal departures over the entire country, except the Southeast and the Pacific States. Resultant-wind velocities at 5 p. m. were lower than those for 5 a. m. at 1.5 kilometers, except in the Northeast and far Northwest. But at 3 kilometers 5 p. m. velocities were higher than at 5 a. m. over most of the country, except the West Gulf and southern Rocky Mountain States.

Table 3 shows the individual maximum wind velocities recorded during September over the United States. None of the velocities recorded were unusual, most of them being lower than any recorded during the past several months.

MONTHLY MEAN ISENTROPIC CHART

The mean isentropic chart, θ=312° (chart XII), for September 1939, is dominated by a single large anticyclonic eddy over the southern part of the United States, with its center near Fort Smith, Ark. A broad band of

westerly winds prevails over the northern half of the country.

Except in the far Southwest and the east Gulf States the entire pattern suggests prevailing downslope (subsiding) motion, a fact which helps account for the deficiency of precipitation over most of the country. The dry tongue extending from Illinois into eastern Texas corresponds closely with the belt of maximum precipitation deficiencies, while marked excesses are confined to the region to the left of an observer travelling with the moist current in the Southwest. Much of the precipitation in southern California occurred in connection with a tropical storm which moved inland September 25, but elsewhere in the Southwest abnormal shower activity prevailed throughout the month. There is a relatively inactive moist tongue extending northeastward over the eastern Gulf of Mexico, which may be associated with the increased shower activity on its northern, upslope side, where excesses in precipitation, or smaller deficiencies than elsewhere, prevail.

In drawing chart XII it was found impossible to reconcile in a logical manner the data for Washington, Norfolk, and Lakehurst. It was decided to draw only for the Washington averages, rather than force the pattern into consistency with all the data. The difficulty may be attributed to the fact that at each of these stations soundings were not made on several days, the dates differing for the various stations. The data for Seattle, being based on but 17 observations, were also disregarded.

TABLE 1.—*Mean free-air barometric pressures (P.) in mb., temperatures (T.) in ° C., and relative humidities (R. H.) in percent obtained by airplanes during September 1939*

Stations and elevations in meters above sealevel	Altitude (meters) m. s. l.																											
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
	Number of observations	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity
Coco Solo, C. Z. (15 m.)	25	1,011	25.1	95	957	24.2	83	904	21.9	82	854	19.8	78	806	17.6	77	759	15.6	70	716	13.3	67	636	7.7	73			
Lakehurst, N. J. (39 m.)	24	1,013	15.8	88	959	17.7	66	905	15.3	59	853	13.5	56	804	11.2	51	757	8.9	50	713	6.8	47	630	2.1	43	555	−2.5	42
Norfolk, Va. (10 m.)	26	1,018	20.9	86	963	20.0	71	908	17.2	67	856	14.3	65	807	12.0	58	760	10.0	52	715	7.0	49	633	0.9	46	558	−5.5	44
Pearl Harbor, T. H. (6 m.)	30	1,014	22.6	82	959	20.7	76	905	17.0	75	854	14.0	72	804	11.5	65	757	11.2	43	714	9.1	30	631	2.6	24			
Pensacola, Fla. (13 m.)	27	1,016	22.8	90	960	24.0	73	907	21.2	69	856	18.0	73	807	15.5	63	761	12.9	58	717	10.4	50	635	4.4	48	561	−3.2	48
St. Thomas, V. I. (8 m.)	28	1,016	28.9	72	962	25.0	90	909	22.0	84	857	19.4	76	809	16.9	71	762	14.8	60	718	12.3	51	637	6.8	46			
San Diego, Calif. (10 m.)	29	1,011	20.8	80	955	21.6	70	901	21.6	56	850	19.0	51	802	16.7	47	756	14.0	44	712	11.0	42	631	4.5	41	558	−2.2	38
Seattle, Wash. (10 m.)	23	1,016	15.6	76	960	13.4	74	904	13.5	62	852	11.8	56	803	9.9	46	756	7.6	47	711	5.2	48	628	−0.2	48			

Observations made by U. S. Navy, and taken at 4 a. m., 75th meridian time, except along the Pacific coast and Hawaii where they are made at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

TABLE 1a.—*Mean free-air barometric pressures (P.) in mb., temperatures (T.) in °C., and relative humidities (R. H.) in percent obtained by radiosondes during September 1939*

Altitude (meters) m. s. l	Stations and elevations in meters above sea level																											
	Albuquerque, N. Mex. (1,621 m.)				Atlanta, Ga. (298 m.)				Billings, Mont. (1,089 m.)				Bismarck, N. Dak. (508 m.)				Buffalo, N. Y. (219 m.)				Charleston, S. C. (14 m.)				Denver, Colo. (1,616 m.)				El Paso, Tex. (1,194 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	30	841	18.1	55	28	983	20.2	86	30	892	12.9	54	30	955	10.8	69	29	991	14.2	83	29	1,015	21.8	93	29	840	14.2	58	30	883	21.1	49
500					28	961	22.1	75									29	959	14.8	77	29	960	22.2	78								
1,000					28	907	20.0	75					30	901	15.6	52	29	904	13.0	75	29	906	19.7	76								
1,500					28	855	16.7	79	30	850	14.7	49	30	849	13.3	49	29	852	11.1	71	29	855	16.4	79					30	852	22.4	45
2,000	30	804	18.3	52	28	806	13.7	79	30	800	12.3	47	30	800	10.5	50	29	802	8.8	69	29	806	13.5	75	29	803	16.7	52	30	804	19.7	44
2,500	30	758	15.4	50	28	760	11.2	70	30	753	9.2	46	30	752	7.4	48	29	755	6.4	65	29	759	11.1	65	29	757	14.1	50	30	759	16.1	45
3,000	30	715	11.7	53	28	715	8.9	60	30	709	5.7	48	30	708	4.3	45	28	710	4.2	61	29	715	8.6	59	29	713	10.7	51	30	715	12.0	49
4,000	30	633	3.9	63	28	633	2.7	53	30	627	−1.8	53	30	626	−1.6	42	28	627	−1.7	56	29	633	2.9	54	29	632	3.2	55	30	634	4.2	59
5,000	30	560	−2.5	68	28	560	−2.9	50	30	552	−8.3	50	29	551	−7.9	41	28	552	−7.7	51	29	559	−3.2	50	29	558	−3.7	57	30	560	−1.8	57
6,000	30	493	−7.8	58	28	492	−8.9	46	30	484	−14.9	46	29	484	−14.5	41	28	485	−14.1	49	29	492	−8.7	45	28	490	−9.7	54	30	493	−7.1	46
7,000	29	433	−14.2	51	28	432	−15.5	44	29	424	−21.7	43	29	423	−21.9	42	28	425	−20.9	45	29	432	−15.1	43	27	431	−16.4	50	29	434	−13.3	41
8,000	29	378	−21.5	48	28	378	−22.3	41	29	369	−29.1	42	29	369	−29.5	42	28	370	−28.2	43	27	378	−22.2	43	27	376	−23.6	48	29	380	−20.3	39
9,000	27	329	−29.3	47	28	329	−30.0	41	29	320	−36.9		29	320	−37.3	40	27	321	−36.3	42	27	329	−29.9	43	27	327	−31.4	48	29	331	−27.6	38
10,000	27	286	−37.2	47	28	285	−37.8	40	29	277	−44.2		29	276	−45.1		27	277	−44.1	40	27	285	−37.6	41	27	284	−38.6	48	29	287	−35.6	38
11,000	27	247	−44.7		28	246	−45.6		29	238	−50.2		29	237	−51.5		26	238	−51.2		26	246	−45.4		26	244	−46.4		28	248	−43.4	
12,000	27	212	−51.5		28	211	−52.6		29	204	−54.7		29	203	−55.8		26	204	−56.6		25	212	−52.9		25	211	−53.0		28	213	−50.4	
13,000	26	181	−57.7		28	181	−58.7		28	174	−58.0		29	173	−58.0		26	174	−59.7		23	181	−59.6		25	180	−58.2		28	182	−57.4	
14,000	24	154	−63.1		28	154	−63.7		28	148	−59.5		27	148	−60.0		25	148	−62.0		20	154	−65.1		24	153	−62.3		28	155	−64.0	
15,000	23	131	−67.7		28	130	−67.2		28	126	−61.0		27	126	−61.3		23	126	−63.9		18	130	−68.8		24	130	−66.2		27	132	−69.2	
16,000	21	111	−70.9		28	110	−69.3		27	108	−62.0		24	107	−61.8		23	107	−64.5		18	110	−70.2		24	110	−68.2		27	111	−72.2	
17,000	20	93	−72.0		26	93	−69.9		25	91	−62.3		21	91	−61.4		21	91	−64.2		17	93	−71.0		22	93	−68.1		27	94	−72.6	
18,000	19	79	−69.5		24	79	−68.0		25	78	−61.5		17	78	−60.1		18	77	−62.5		17	78	−69.6		22	79	−66.5		25	79	−70.2	
19,000	9	67	−66.0		20	67	−65.3		22	66	−60.7		15	66	−58.9		12	66	−60.7		14	66	−67.5		19	67	−63.3		21	67	−66.2	
20,000	5	56	−62.8		19	57	−62.8		17	58	−59.7		6	57	−58.0		8	56	−59.6		13	56	−64.4		15	57	−60.8		18	57	−62.2	
21,000					9	48	−60.2		10	48	−58.2										8	48	−61.7		8	48	−58.6		6	48	−58.8	
22,000					5	41	−57.8		5		−57.0										6	40	−60.6		6	42	−56.8					

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels; also, the humidity data are not used in daily observations when the temperature is below −40.0° C.

TABLE 1a.—*Mean free-air barometric pressures (P.) in mb., temperatures (T.) in °C., and relative humidities (R. H.) in percent obtained by radiosondes during September 1939*—Continued

Altitude (meters) m. s. l.	Stations and elevations in meters above sea level																											
	Ely, Nev. (1909 m)				Joliet, Ill. (178 m)				Medford, Oreg. (401 m)				Miami, Fla. (4 m)				Minneapolis, Minn. (253 m)				Nashville, Tenn. (180 m)				Oakland, Calif. (2 m)				Oklahoma City, Okla. (391 m)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	30	812	9.6	69	28	995	15.8	80	30	968	14.8	61	29	1015	23.4	95	30	984	14.9	73	30	996	20.2	75	30	1013	15.3	82	29	970	21.7	55
500					28	958	20.2	62	30	956	15.9	60	29	959	23.5	82	30	957	15.6	65	30	960	22.3	65	30	957	18.0	68	29	957	23.3	51
1,000					28	904	18.2	59	30	902	15.9	56	29	906	20.6	78	30	903	14.4	60	30	906	20.1	63	30	902	18.5	50	29	905	23.3	45
1,500					28	853	15.9	53	30	850	12.8	55	29	855	17.7	75	30	850	12.1	58	30	855	17.2	63	30	851	16.4	45	29	854	20.5	46
2,000	30	803	11.7	64	28	804	13.0	50	30	800	10.5	55	29	806	14.9	72	30	801	9.7	54	30	806	14.3	62	30	802	13.2	44	29	805	17.3	46
2,500	30	756	11.6	56	28	756	10.2	50	30	753	8.0	51	29	760	12.1	70	30	754	7.0	51	30	760	12.0	56	30	755	10.1	43	29	759	13.7	50
3,000	30	712	8.3	55	28	712	7.5	50	30	708	5.0	45	29	715	9.2	68	30	709	4.1	50	30	716	9.2	53	30	711	7.1	41	29	715	10.7	48
4,000	29	630	0.9	58	28	630	1.3	52	30	626	−1.5	40	29	634	3.9	61	30	626	−1.7	50	30	634	2.8	49	30	629	0.9	40	29	634	4.0	47
5,000	28	556	−5.8	57	28	556	−5.4	52	30	552	−7.8	38	29	560	−1.7	57	30	552	−7.7	47	30	559	−2.9	44	30	555	−6.1	38	29	560	−2.0	47
6,000	27	488	−11.3	50	28	489	−11.5	46	30	484	−14.9	36	28	493	−7.9	56	29	484	−14.2	45	30	492	−8.8	42	30	487	−13.0	37	29	493	−8.0	41
7,000	27	428	−17.6	42	28	428	−18.3	40	30	424	−22.3	35	28	433	−14.2	53	29	424	−21.4	43	30	432	−15.5	39	30	427	−19.9	35	29	433	−14.6	38
8,000	26	374	−25.3	41	28	374	−25.7	39	30	369	−29.7	35	27	379	−20.8	52	28	370	−28.8	42	30	378	−22.6	37	30	372	−27.7	34	29	379	−22.5	37
9,000	26	325	−33.0	40	28	325	−33.6	39	30	320	−37.1	34	27	330	−27.8	49	27	320	−36.4	40	30	329	−30.3	37	29	323	−35.2	34	29	330	−30.5	35
10,000	27	282	−40.3	38	28	281	−41.4	38	30	276	−44.5	----	27	287	−35.7	46	26	277	−43.6	----	30	285	−37.9	37	29	280	−42.4	----	29	286	−38.0	33
11,000	26	243	−47.2	----	28	242	−48.6	----	30	237	−50.4	----	27	248	−43.5	----	26	238	−50.0	----	30	246	−45.3	----	29	241	−48.5	----	29	246	−44.9	----
12,000	26	208	−52.9	----	28	208	−54.2	----	30	203	−55.0	----	27	213	−51.0	----	23	204	−55.0	----	30	212	−52.2	----	28	206	−53.6	----	29	212	−51.2	----
13,000	26	178	−57.3	----	28	177	−58.9	----	30	174	−57.5	----	27	182	−58.4	----	23	174	−57.8	----	30	181	−57.8	----	28	176	−56.4	----	29	182	−57.2	----
14,000	26	152	−60.6	----	28	151	−62.4	----	30	148	−58.8	----	27	155	−64.5	----	22	149	−59.8	----	29	154	−62.3	----	27	150	−59.3	----	28	154	−62.4	----
15,000	26	129	−63.4	----	28	128	−65.0	----	28	126	−60.9	----	27	132	−68.3	----	20	127	−61.0	----	29	131	−66.4	----	27	128	−62.0	----	27	131	−66.6	----
16,000	26	110	−65.0	----	26	109	−66.5	----	28	108	−62.1	----	27	112	−69.9	----	19	108	−61.4	----	29	111	−69.2	----	27	109	−64.1	----	26	111	−68.9	----
17,000	26	93	−64.9	----	24	92	−66.4	----	25	91	−62.5	----	25	94	−70.3	----	17	91	−61.4	----	27	94	−69.8	----	27	93	−64.6	----	22	94	−69.6	----
18,000	23	79	−64.3	----	23	78	−64.2	----	24	78	−61.8	----	22	79	−69.1	----	16	78	−60.0	----	27	79	−68.8	----	26	78	−64.0	----	21	79	−69.1	----
19,000	14	67	−62.5	----	21	66	−61.9	----	20	66	−60.7	----	21	67	−67.2	----	13	66	−58.4	----	24	67	−66.3	----	23	67	−62.4	----	20	67	−66.0	----
20,000	7	57	−60.5	----	13	56	−59.2	----	11	57	−59.5	----	17	57	−64.0	----	9	56	−56.8	----	20	57	−63.6	----	17	57	−60.8	----	18	56	−62.4	----
21,000					9	47	−57.3	----					10	48	−61.2	----					16	48	−60.9	----	11	48	−59.4	----	12	48	−59.8	----
22,000					5	40	−55.4	----					6	41	−58.9	----					12	41	−58.6	----	5	41	−58.6	----	8	41	−57.1	----
23,000																					8	35	−56 3	----								

Altitude (meters) m. s. l.	Stations and elevations in meters above sea level																											
	Omaha, Nebr. (300 m)				Phoenix, Ariz. (339 m)				St. Louis, Mo. (176 m)				San Juan, P. R. (18 m)				Sault Ste. Marie, Mich. (221 m.)				Spokane, Wash. (597 m.)				Swan Island, W. I. (10 m.)				Washington,[1] D. C. (7 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	30	980	17.7	60	29	972	24.0	68	30	996	20.5	69	30	1012	24.9	89	30	989	10.5	93	29	946	11.8	63	29	1010	26.3	87	26	1017	17.7	86
500	30	958	19.4	55	29	955	26.8	57	30	959	22.9	55	30	958	23.2	87	30	957	11.7	86	----				29	956	22.7	88	26	960	17.9	76
1,000	30	904	19.2	50	29	902	25.1	50	30	906	20.8	52	30	905	20.3	84	30	901	10.0	79	29	901	14.6	50	29	903	19.4	82	26	905	16.0	66
1,500	30	853	17.5	48	29	852	21.5	51	30	855	18.2	51	30	854	17.4	77	30	848	7.5	74	29	850	12.0	50	29	852	16.5	79	26	854	13.8	58
2,000	30	804	14.9	49	29	804	18.1	53	30	806	15.1	51	30	805	14.9	70	30	798	5.6	68	29	800	8.6	54	29	803	13.5	74	26	805	12.4	52
2,500	30	757	12.0	50	29	758	14.7	53	30	759	12.0	48	30	759	12.7	64	30	750	3.4	65	29	753	5.1	59	29	756	10.5	70	25	758	10.0	50
3,000	30	713	8.9	50	29	714	11.3	53	30	715	8.8	48	30	715	10.0	61	30	705	1.4	61	29	708	2.0	62	29	712	7.5	68	25	713	7.2	48
4,000	30	631	2.6	48	29	633	4.3	57	30	633	2.2	51	29	633	4.5	56	28	622	−4.3	58	29	625	−3.4	55	28	630	2.0	65	25	631	1.6	44
5,000	30	558	−3.8	44	29	559	−1.8	54	30	559	−4.3	49	28	560	−1.2	53	28	548	−10.0	56	28	550	−10.0	51	27	556	−3.4	64	25	556	−4.0	38
6,000	30	490	−10.0	39	29	492	−7.5	46	30	491	−10.4	45	28	493	−7.3	50	28	480	−16.1	54	28	482	−16.8	49	27	490	−8.9	61	24	489	−9.8	38
7,000	30	430	−16.6	36	28	433	−13.8	40	30	431	−17.4	45	28	433	−13.7	48	28	420	−23.1	53	28	421	−23.8	50	27	430	−14.7	60	23	429	−16.2	41
8,000	30	376	−24.1	34	28	378	−20.5	38	30	376	−25.2	41	28	379	−20.5	46	28	356	−30.5	52	28	366	−31.0	50	27	376	−21.1	57	22	375	−22.7	42
9,000	30	327	−32.1	33	28	330	−27.9	37	30	327	−33.0	40	27	330	−27.5	44	28	317	−38.2	52	28	318	−38.8	50	27	327	−28.2	55	21	327	−30.0	43
10,000	30	284	−39.7	33	28	287	−35.7	36	30	283	−40.8	40	27	287	−34.9	44	28	273	−45.7	50	28	274	−46.4	----	27	284	−35.7	54	20	284	−37.4	39
11,000	30	244	−46.6	----	28	248	−43.1	----	30	244	−48.1	----	27	248	−42.4	----	28	235	−52.3	----	28	235	−52.6	----	27	246	−43.6	----	17	245	−44.8	----
12,000	30	210	−52.7	----	28	213	−50.2	----	29	209	−54.5	----	27	213	−49.7	----	26	201	−56.0	----	28	201	−56.2	----	27	211	−51.4	----	17	210	−51.9	----
13,000	30	179	−57.4	----	28	182	−56.6	----	28	178	−59.7	----	27	183	−56.6	----	25	172	−58.0	----	27	172	−57.7	----	27	180	−59.1	----	16	180	−57.9	----
14,000	29	153	−61.1	----	28	155	−62.2	----	28	152	−63.9	----	27	156	−62.4	----	25	146	−59.7	----	27	146	−58.4	----	27	153	−66.4	----	12	153	−62.1	----
15,000	29	130	−64.0	----	28	132	−66.7	----	27	128	−67.4	----	27	132	−67.1	----	24	124	−60.9	----	27	124	−59.4	----	27	130	−72.2	----	11	130	−65.1	----
16,000	28	110	−66.0	----	28	112	−69.5	----	25	109	−69.1	----	27	112	−70.4	----	22	106	−61.5	----	27	106	−59.5	----	27	109	−75.1	----	6	110	−67.7	----
17,000	28	94	−66.1	----	28	94	−69.4	----	24	92	−68.8	----	27	94	−72.3	----	19	90	−60.8	----	26	90	−59.3	----	26	92	−75.8	----				
18,000	26	79	−64.7	----	28	80	−68.0	----	22	78	−66.3	----	27	79	−72.9	----	13	76	−59.5	----	18	77	−58.5	----	25	77	−75.2	----				
19,000	19	67	−62.8	----	22	68	−65.5	----	18	66	−63.6	----	24	67	−71.7	----	7	65	−57.5	----	6	66	−57.9	----	24	65	−72.2	----				
20,000	10	56	−60.5	----	16	57	−62.7	----	8	56	−61.0	----	21	57	−69.9	----									19	55	−69.6	----				
21,000	9	48	−58.5	----	14	49	−60.0	----					20	48	−66.7	----									12	46	−67.4	----				
22,000													13	40	−63.4	----									6	39	−66.1	----				
23,000													7	34	−60.3	----																

[1] Navy.

Observations taken about 4 a. m., 75th meridian time.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels; also, the humidity data are not used in daily observations when the temperature is below −40.0° C.

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (E. S. T.) during September 1939*

[Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second (superior figures indicate number of observations)]

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.)		Albuquerque, N. Mex. (1,554 m.)		Atlanta, Ga. (302 m.)		Billings, Mont. (1,095 m.)		Boise, Idaho (850 m.)		Brooklyn, N. Y. (15 m.)		Brownsville, Tex. (7 m.)		Buffalo, N. Y. (220 m.)		Burlington, Vt. (132 m.)		Charleston, S. C. (18 m.)		Cheyenne, Wyo. (1,873 m.)		Chicago, Ill. (192 m.)		Cincinnati, Ohio (157 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	154^{30}	1.7	218^{30}	1.8	28^{29}	0.6	291^{29}	0.8	299^{30}	2.3	189^{29}	2.7	106^{29}	3.8	267^{28}	2.0	210^{28}	1.2	41^{30}	0.9	229^{30}	2.8	287^{29}	0.7	256^{30}	1.7
500	.....	.....	.....	.....	39^{29}	.8	.....	.....	.....	.....	232^{28}	3.3	115^{30}	4.2	261^{30}	3.2	246^{28}	2.4	59^{30}	1.4	.....	.....	273^{29}	.9	252^{29}	3.2
1,000	148^{30}	3.4	.....	.....	74^{29}	1.3	.....	.....	294^{30}	2.0	260^{28}	4.9	124^{30}	2.9	251^{30}	5.4	276^{28}	5.0	9^{28}	1.2	.....	.....	243^{29}	2.6	248^{29}	4.3
1,500	153^{30}	3.2	.....	.....	68^{28}	.6	243^{29}	4.3	287^{30}	1.0	282^{26}	5.4	123^{33}	2.4	256^{24}	7.9	285^{27}	6.9	330^{26}	1.6	.....	.....	258^{27}	5.6	255^{29}	5.0
2,000	154^{30}	3.3	212^{30}	2.4	70^{26}	1.0	257^{29}	2.4	278^{30}	1.5	284^{26}	6.6	126^{31}	2.0	265^{24}	9.4	288^{21}	8.8	337^{21}	2.3	228^{25}	3.0	269^{24}	6.0	263^{29}	5.8
2,500	157^{30}	2.9	202^{30}	2.8	325^{22}	1.0	269^{27}	4.3	264^{29}	2.3	285^{26}	3.0	119^{10}	2.1	278^{21}	9.2	289^{14}	10.4	325^{19}	3.0	252^{26}	3.4	277^{21}	7.4	273^{29}	7.3
3,000	162^{30}	1.9	211^{28}	2.7	343^{18}	1.8	262^{26}	7.0	248^{26}	5.4	276^{19}	7.6	103^{16}	2.5	282^{18}	9.3	302^{12}	10.3	323^{18}	2.3	261^{25}	4.8	277^{19}	8.8	282^{29}	8.2
4,000	158^{29}	2.1	226^{24}	3.3	305^{17}	1.9	268^{25}	10.7	249^{19}	7.3	.....	.....	71^{12}	3.0	290^{14}	10.0	.....	.....	288^{14}	3.8	272^{26}	8.6	289^{15}	9.3	280^{23}	8.6
5,000	212^{23}	1.9	233^{22}	4.0	326^{16}	2.4	277^{21}	11.8	247^{14}	9.5	.....	.....	64^{10}	2.8	.....	.....	.....	.....	277^{19}	3.0	266^{23}	10.1	.....	.....	300^{16}	8.3
6,000	252^{21}	1.9	232^{19}	4.4	326^{15}	3.2	275^{18}	12.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	268^{21}	10.0	.....	.....	300^{13}	11.3
8,000	294^{19}	4.8	226^{13}	4.4	355^{13}	2.3	272^{14}	16.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	261^{17}	14.2	.....	.....	303^{10}	13.2
10,000	308^{17}	9.0	257^{10}	5.0	.....	.....	270^{10}	21.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	280^{13}	18.7	.....	.....	.....	.....
12,000	301^{12}	8.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14,000	312^{11}	7.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)		Fargo N. Dak. (283 m.)		Greensboro, N. Car. (271 m.)		Havre, Mont. (766 m.)		Houston, Tex. (21 m.)		Huron, S. Dak. (393 m.)		Las Vegas, Nev. (570 m.)		Little Rock, Ark. (82 m.)		Medford, Oreg. (410 m.)		Miami, Fla. (10 m.)		Minneapolis, Minn. (261 m.)		Nashville, Tenn. (194 m.)		New Orleans, La. (19 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	136^{30}	0.8	236^{30}	1.4	173^{29}	0.3	269^{27}	3.3	135^{30}	3.2	220^{30}	2.0	115^{29}	1.8	132^{30}	2.1	306^{29}	1.4	111^{30}	2.2	235^{29}	1.8	281^{29}	0.7	71^{30}	1.4
500	.....	.....	250^{30}	1.7	177^{29}	.5	.....	.....	129^{30}	3.5	222^{30}	1.8	.....	.....	155^{30}	2.7	308^{29}	1.4	119^{30}	2.5	257^{29}	2.4	239^{29}	.7	109^{30}	2.5
1,000	.....	.....	256^{30}	2.8	243^{29}	.8	264^{27}	4.4	117^{30}	2.7	235^{30}	2.3	118^{29}	1.9	166^{30}	2.1	307^{29}	1.2	112^{30}	1.4	234^{28}	3.8	243^{29}	.8	104^{30}	2.8
1,500	142^{30}	1.3	260^{29}	4.9	264^{29}	.8	264^{27}	6.6	106^{29}	2.2	253^{28}	4.1	153^{29}	1.6	208^{29}	1.3	217^{29}	.6	91^{30}	.7	250^{28}	4.8	240^{28}	.6	83^{28}	2.9
2,000	153^{30}	1.9	271^{26}	7.0	273^{28}	2.0	264^{26}	7.5	93^{28}	2.4	263^{26}	5.1	185^{30}	1.4	264^{30}	1.0	200^{28}	1.8	97^{30}	.5	264^{27}	7.1	263^{27}	.9	69^{28}	3.2
2,500	139^{30}	2.6	281^{23}	8.5	299^{28}	2.9	263^{25}	8.6	96^{24}	2.9	266^{25}	7.4	211^{29}	3.1	307^{27}	.6	212^{27}	2.3	189^{26}	.7	270^{25}	9.2	285^{26}	1.1	76^{23}	3.4
3,000	125^{30}	2.8	283^{24}	11.2	313^{25}	4.2	268^{24}	9.8	84^{23}	2.8	273^{24}	8.2	208^{29}	4.5	319^{27}	1.3	221^{27}	2.6	209^{27}	1.3	269^{23}	10.7	299^{26}	1.9	64^{23}	3.7
4,000	128^{28}	1.6	280^{22}	12.3	311^{24}	5.9	280^{20}	11.2	86^{17}	4.8	274^{23}	11.2	213^{29}	6.9	230^{24}	1.3	214^{25}	1.7	202^{24}	2.4	281^{19}	13.2	352^{20}	3.6	79^{13}	3.6
5,000	204^{23}	1.9	285^{20}	14.5	306^{19}	7.5	283^{15}	13.2	71^{14}	3.9	280^{20}	12.4	219^{28}	7.5	261^{20}	2.6	242^{23}	1.0	189^{20}	3.5	291^{14}	15.0	335^{19}	3.7	.....	.....
6,000	245^{19}	2.6	283^{17}	16.2	288^{17}	7.8	287^{13}	12.7	68^{12}	3.3	281^{20}	14.6	223^{23}	8.5	269^{20}	3.4	268^{23}	.8	181^{20}	3.6	290^{14}	16.3	330^{17}	5.7	.....	.....
8,000	278^{17}	4.6	281^{16}	21.0	287^{13}	9.7	.....	.....	.....	.....	278^{19}	18.8	225^{30}	13.5	266^{17}	4.0	254^{21}	1.1	159^{21}	4.4	.....	.....	314^{13}	6.8	.....	.....
10,000	.....	.....	.....	.....	299^{10}	11.1	.....	.....	.....	.....	285^{15}	22.6	230^{17}	19.5	347^{10}	1.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	285^{12}	25.2	241^{17}	25.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	237^{15}	20.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	244^{13}	10.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Altitude (meters) m. s. l.	Oakland, Calif. (8 m.)		Oklahoma City, Okla. (402 m.)		Omaha, Nebr. (306 m.)		Reno, Nev. (1,346 m.)		St. Louis, Mo. (170 m.)		Salt Lake City, Utah (1,294 m.)		San Diego, Calif. (15 m.)		San Juan, P. R. (16 m.)		Sault Ste. Marie, Mich. (198 m.)		Seattle, Wash. (14 m.)		Spokane, Wash. (603 m.)		Washington, D. C. (10 m.)		Winslow, Ariz. (1,488 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	270^{29}	3.9	193^{30}	3.2	200^{30}	2.5	245^{30}	0.9	200^{29}	1.6	295^{27}	1.1	283^{27}	3.2	83^{30}	4.6	271^{29}	1.6	307^{28}	2.0	216^{30}	2.2	177^{30}	1.1	211^{30}	2.7
500	307^{28}	1.8	193^{30}	3.2	203^{30}	3.7	.....	.....	214^{29}	1.9	.....	.....	226^{27}	1.4	90^{30}	6.4	238^{29}	2.4	297^{24}	1.1	.....	.....	214^{30}	2.1	.....	.....
1,000	80^{29}	.2	188^{30}	3.5	196^{30}	4.2	.....	.....	226^{29}	3.0	.....	.....	147^{26}	2.4	110^{29}	4.9	229^{28}	4.8	275^{24}	1.5	223^{30}	2.8	244^{29}	4.1	.....	.....
1,500	183^{28}	1.2	200^{29}	4.5	220^{30}	5.3	231^{30}	.7	244^{29}	4.2	278^{27}	1.2	144^{25}	3.6	109^{27}	4.7	254^{21}	5.8	229^{23}	2.4	225^{30}	3.0	275^{27}	5.0	.....	.....
2,000	162^{25}	2.3	206^{29}	4.6	245^{29}	7.1	159^{30}	1.3	255^{29}	5.3	238^{27}	1.6	154^{23}	2.6	103^{24}	4.7	265^{19}	8.2	243^{19}	2.1	229^{27}	3.8	297^{25}	6.2	204^{30}	2.5
2,500	155^{27}	2.8	208^{29}	4.8	255^{28}	8.3	180^{29}	2.5	263^{28}	6.5	221^{26}	3.2	175^{23}	2.8	97^{23}	4.8	274^{18}	9.1	262^{17}	2.3	247^{26}	4.4	294^{23}	6.8	199^{30}	2.8
3,000	161^{26}	3.4	211^{28}	3.6	263^{27}	9.6	200^{28}	3.6	271^{26}	7.9	222^{26}	3.5	192^{23}	3.7	89^{23}	5.1	274^{16}	10.4	267^{17}	3.8	255^{22}	5.9	292^{24}	7.5	194^{30}	4.1
4,000	172^{26}	3.1	232^{26}	2.3	272^{24}	10.9	213^{26}	4.3	278^{30}	8.3	222^{25}	5.8	196^{19}	5.1	86^{21}	5.0	288^{13}	12.6	290^{17}	4.0	256^{20}	8.3	294^{23}	7.8	205^{28}	4.7
5,000	193^{26}	4.9	256^{20}	3.6	277^{25}	11.6	217^{26}	4.9	292^{17}	7.6	238^{22}	6.3	212^{16}	7.5	91^{20}	5.5	.....	.....	284^{17}	6.8	272^{19}	9.2	.....	.....	220^{24}	4.2
6,000	210^{22}	5.4	265^{19}	3.7	279^{21}	12.5	214^{26}	6.3	290^{14}	7.8	257^{20}	7.0	212^{13}	8.8	88^{18}	5.1	.....	.....	267^{14}	10.0	280^{18}	10.4	.....	.....	235^{21}	5.9
8,000	219^{19}	7.7	282^{17}	6.7	282^{19}	14.6	219^{23}	8.7	.....	.....	260^{14}	8.8	.....	.....	90^{14}	6.1	.....	.....	.....	.....	.....	.....	.....	.....	239^{20}	9.4
10,000	209^{13}	10.1	290^{14}	7.8	286^{17}	17.4	227^{17}	12.1	.....	.....	.....	.....	.....	.....	71^{12}	7.7	.....	.....	.....	.....	.....	.....	.....	.....	256^{13}	15.5
12,000	.....	.....	.....	.....	289^{10}	16.4	224^{10}	17.4	.....	.....	.....	.....	.....	.....	47^{10}	7.6	.....	.....	.....	.....	.....	.....	.....	.....	258^{13}	16.9
14,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	266^{11}	13.3
16,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	253^{10}	5.6

TABLE 3.—*Maximum free-air wind velocities (M. P. S.), for different sections of the United States based on pilot balloon observations during September 1939*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast [1]	33.1	WNW	1,180	6	Boston, Mass.	38.4	WNW	4,660	10	Cleveland, Ohio	57.6	WSW	12,400	28	Cleveland, Ohio.
East-Central [2]	25.5	WNW	2,360	10	Washington, D. C.	29.0	WSW	2,950	29	Cincinnati, Ohio	36.0	W	9,720	25	Greensboro, N. C.
Southeast [3]	19.7	N	2,090	14	Charleston, S. C.	24.9	NNE	5,000	14	Jacksonville, Fla.	37.0	WSW	10,540	30	Jacksonville, Fla.
North-Central [4]	37.7	NNW	1,970	3	Rapid City, S. Dak.	36.0	NW	4,130	29	Rapid City, S. Dak.	52.8	W	13,890	11	Fargo, N. Dak.
Central [5]	32.3	WSW	790	12	Moline, Ill.	34.0	WNW	4,960	10	Chicago, Ill.	39.0	WSW	13,080	26	Omaha, Nebr.
South-Central [6]	30.2	SW	1,730	3	Amarillo, Tex.	25.6	WSW	2,870	29	Little Rock, Ark.	43.0	SW	11,450	23	New Orleans, La.
Northwest [7]	26.3	WSW	1,770	27	Pocatello, Idaho	35.0	W	4,820	8	Havre, Mont.	49.6	WSW	10,220	4	Billings, Mont.
West-Central [8]	25.4	WNW	2,480	15	Cheyenne, Wyo.	41.8	SW	3,560	1	Modena, Utah	56.0	NW	19,440	19	Denver, Colo.
Southwest [9]	28.6	SSE	816	24	San Diego, Calif.	29.2	SSW	4,940	13	Las Vegas, Nev.	51.2	SSW	9,700	12	Las Vegas, Nev.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during September 1939, classified according to the potential temperatures (10-degree intervals between 300° and 409° A.) with which they are identified. (Based on radiosonde observations)*

Potential temperatures, ° A.	Albuquerque, N. Mex.			Atlanta, Ga.			Billings, Mont.			Bismarck, N. Dak			Charleston, S. C.			Denver, Colo.			El Paso, Tex.		
	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature
300–309										1	7.1	−36.0									
310–319							1	10.1	−55.0	1	7.7	−35.0									
320–329							10	10.2	−50.2	17	10.5	−51.0				2	9.6	−44.0			
330–339	13	10.4	−44.9	3	11.2	−51.0	20	11.1	−49.4	21	11.0	−51.7	5	10.7	−47.0	11	11.0	−50.3	4	10.4	−42.8
340–349	15	12.3	−55.5	24	12.9	−58.4	13	12.3	−58.7	17	11.9	−54.6	17	12.3	−56.1	21	12.1	−52.2	14	11.6	−48.6
350–359	14	13.6	−61.8	16	13.6	−63.4	11	12.8	−57.3	3	13.4	−62.0	15	13.9	−65.2	8	13.5	−60.9	22	13.8	−64.3
360–369	11	14.7	−67.2	17	14.7	−67.2	5	14.0	−61.2	3	13.8	−61.3	9	16.1	−69.9	10	14.6	−66.4	14	15.2	−70.9
370–379	10	15.7	−70.1	14	15.4	−69.1	6	14.5	−61.7	5	14.8	−63.2	4	15.5	−71.2	9	15.3	−68.4	13	16.0	−73.2
380–389	6	16.5	−73.8	7	16.2	−71.1	4	14.9	−61.5	4	14.9	−61.5	5	16.2	−70.8	10	15.9	−69.4	8	16.4	−73.6
390–399	3	17.1	−74.0	8	16.8	−72.1	6	15.8	−63.7	3	16.1	−66.0	5	16.9	−73.2	8	16.6	−70.0	7	17.0	−74.0
400–409	9	17.3	−71.8	5	17.0	−68.0	1	16.4	−63.0	5	16.2	−62.8	3	17.1	−69.3	4	16.8	−68.5	4	17.4	−73.2
Weighted means		14.0	−62.1		14.5	−64.8		12.5	−55.9		12.2	−54.2		14.2	−63.6		13.8	−60.6		14.5	−65.2
Mean potential temperature (weighted), °A	362.4			368.2			350.7			347.5			360.4			361.6			364.7		

Potential temperatures, ° A.	Ely, Nev.			Joliet, Ill.			Medford, Oreg.			Miami, Fla.			Minneapolis, Minn.			Nashville, Tenn.			Oakland, Cal.		
	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature
300–309																			3	6.3	−28.3
310–319	1	7.9	−34.0				2	8.3	−42.0							1	8.0	−28.0	3	7.7	−35.7
320–329	3	9.6	−43.7	12	10.0	−47.3	14	9.7	−45.5				10	10.1	−49.6	2	9.0	−36.0	8	9.1	−39.1
330–339	17	10.6	−47.2	22	10.9	−49.6	26	11.1	−53.0	1	10.4	−43.0	11	11.1	−52.0	5	11.3	−52.0	22	10.7	−47.9
340–349	19	12.5	−55.5	16	12.1	−55.9	14	12.2	−56.1	10	12.9	−60.2	14	12.0	−56.0	22	12.0	−53.1	13	12.2	−56.4
350–359	9	13.0	−58.8	11	13.3	−59.5	6	13.3	−61.7	25	13.9	−62.2	2	13.2	−61.5	9	13.6	−61.8	5	12.6	−55.2
360–369	8	14.0	−61.4	14	14.6	−66.1	3	13.9	−62.3	18	14.8	−67.4	6	13.8	−62.0	9	14.8	−68.0	7	13.7	−59.9
370–379	9	15.1	−65.6	3	15.4	−69.7	8	14.4	−60.9	9	15.6	−70.9	5	14.5	−63.0	17	15.3	−67.8	5	14.1	−58.2
380–389	10	16.0	−64.6	6	15.7	−67.7	3	15.1	−62.0	7	16.2	−70.6	1	15.8	−68.0	7	16.3	−72.6	7	15.6	−65.3
390–399	8	16.0	−66.2	7	16.3	−67.7	6	15.8	−63.5	3	16.7	−71.3	2	15.7	−64.0	4	16.5	−69.0	10	16.0	−64.2
400–409	4	16.7	−65.8	2	16.9	−67.0	7	16.6	−64.7	4	17.3	−71.8	3	16.2	−63.3	5	17.2	−71.4	7	16.6	−65.1
Weighted means		13.3	−57.6		12.8	−57.6		12.4	−54.9		14.6	−65.5		12.4	−56.4		13.9	−61.7		12.5	−53.7
Mean potential temperature (weighted)	362.7			352.7			351.7			364.5			350.1			362.5			355.2		

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during September 1939, classified according to the potential temperatures (10-degree intervals between 300° and 409° A.) with which they are identified. (Based on radiosonde observations)*—Continued.

Potential temperatures A.	Oklahoma City, Okla.			Omaha, Nebr.			Phoenix, Ariz.			San Juan, P. R.			Sault Ste. Marie, Mich.			St. Louis, Mo.			Spokane, Wash.			Swan Island, W. I.		
	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature	Number of cases	Mean altitude	Mean temperature
310–319				1	7.7	−34.0							4	7.5	−34.3				2	8.2	−38.0			
320–329	3	9.4	−40.3	8	9.9	−45.8							22	10.2	−52.7	2	10.8	−53.5	18	9.9	−47.6			
330–339	8	10.7	−46.8	16	10.1	−41.9	5	10.8	−46.6	3	11.2	−51.6	10	11.3	−56.2	17	10.9	−49.5	24	11.2	−54.8			
340–349	17	12.1	−53.9	17	12.1	−55.0	15	11.8	−50.5	10	12.3	−55.9	8	11.8	−54.9	17	12.3	−57.2	11	12.3	−58.7	9	12.9	−61.1
350–359	14	13.4	−59.9	12	13.2	−58.2	17	13.5	−61.2	13	13.4	−61.3	5	13.1	−61.0	9	13.8	−64.3	4	13.2	−61.8	25	14.3	−69.7
360–369	13	14.7	−66.5	8	14.2	−62.5	11	14.8	−67.3	14	14.7	−66.5	8	14.0	−62.1	11	14.9	−70.1	3	13.6	−59.3	16	15.4	−73.4
370–379	7	15.7	−70.6	9	15.3	−67.2	13	15.7	−69.9	5	15.6	−71.0	3	14.3	−60.0	9	15.0	−66.3	4	14.6	−61.2	10	16.1	−76.4
380–389	9	15.0	−69.8	7	15.8	−67.4	10	16.4	−71.9	7	16.5	−73.6	3	15.7	−66.3	6	16.1	−71.0	3	15.0	−62.0	6	16.9	−76.3
390–399	5	16.8	−71.4	12	16.3	−67.3	7	16.7	−70.6	6	16.9	−72.0				10	16.2	−68.8	3	15.8	−62.7	1	17.2	−77.0
400–409	3	17.6	−72.7	2	17.2	−70.5	5	17.4	−71.6	2	17.2	−72.5	1	16.3	−63.0	5	16.9	−68.8				5	17.7	−77.4
Weighted means		13.7	−60.9		13.1	−56.9		14.2	−60.7		14.5	−64.8		11.6	−54.6		13.8	−61.9		11.7	−54.7		15.1	−71.6
Mean potential temperature (weighted)	360.5			357.4			362.3			364.6			340.5			360.5			342.5			364.6		

LATE REPORTS FOR AUGUST 1939

Altitude (meters) m. s. l.	Bismarck, N. Dak. (508 m.)				Charleston, S. C. (14 m.)				Sault Ste. Marie, Mich. (221 m.)				Altitude (meters) m. s. l.	Bismarck, N. Dak. (508 m.)				Charleston, S. C. (14 m.)				Sault Ste. Marie, Mich. (221 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity		Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	955	15.9	70	30	1.014	22.6	95	30	988	14.3	95	10,000	29	279	−43.0		28	288	−33.6	40	29	277	−43.7	
500					30	959	23.1	79	30	956	16.0	82	11,000	29	241	−48.9		28	249	−41.3		29	238	−49.6	
1,000	31	902	20.4	49	30	905	21.0	75	30	901	14.6	77	12,000	29	206	−53.8		28	215	−48.9		29	204	−53.7	
1,500	31	851	17.6	48	30	854	18.0	74	30	849	11.6	79	13,000	29	176	−56.5		27	184	−55.8		29	174	−55.7	
2,000	31	802	14.2	52	30	806	15.3	73	30	800	8.8	78	14,000	28	150	−57.8		24	157	−61.6		29	149	−57.2	
2,500	31	756	10.8	54	30	760	12.6	71	30	753	6.3	71	15,000	27	128	−58.8		24	133	−65.9		29	127	−58.3	
3,000	31	711	7.8	53	30	716	10.0	69	30	708	3.6	66	16,000	23	109	−59.9		24	113	−68.3		27	108	−58.7	
4,000	31	630	1.4	48	30	634	4.5	67	30	625	−2.0	58	17,000	22	92	−60.0		23	96	−67.4		23	92	−58.3	
5,000	30	555	−5.5	44	30	561	−0.8	61	30	551	−7.5	48	18,000	21	79	−58.6		21	81	−65.5		14	78	−57.4	
6,000	30	488	−12.6	43	29	494	−6.4	57	29	484	−13.1	44	19,000	19	67	−56.6		19	68	−63.9		9	67	−56.0	
7,000	30	427	−19.8	41	29	434	−12.3	50	29	423	−20.3	42	20,000	14	57	−54.9		12	58	−62.2		6	57	−54.9	
8,000	30	373	−27.4	39	28	380	−18.8	46	29	369	−28.2	41	21,000	10	48	−52.9		8	49	−60.9					
9,000	30	323	−35.6	39	28	332	−25.8	46	29	320	−36.2	40	22,000	5	41	−51.9		8	42	−59.2					

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

The principal floods during August and September 1939 occurred in the Southeastern States as the result of the passage inland of a tropical disturbance over extreme northwestern Florida on August 12–13. This disturbance remained practically stationary over Alabama until the 17th when it began to move slowly northeastward. Heavy precipitation accompanied the storm, the greatest amounts being recorded in extreme northwestern Florida and central and southern Alabama. Moderately heavy rains over Georgia, North and South Carolina, and portions of southern Virginia accompanied the slow northeastward progress of the disturbance.

An interesting feature of this cyclone of tropical origin was, that after its passage inland, it maintained an intense cyclonic circulation to very high levels for several days, the center of the circulation aloft being almost directly above the center at the surface. Pilot-balloon observations at Birmingham, Ala., on the 13th showed that east-southeast winds prevailed at all levels to and including 14,000 feet. At 12,000 feet the highest velocity, 63 miles per hour, was observed. At the same time, Pensacola, Fla., had west-northwest winds at the same levels with a maximum velocity of 54 miles per hour also at 12,000 feet.

Except for the region mentioned above, rains over the country during August were scattered and resulted mainly in minor flooding in Kansas and some local floods in southern New Mexico.

September was unusually dry over the country except for the extreme Southwestern States, which had considerably more than normal rainfall and resulted in some local flooding, and Louisiana and Mississippi where the rainfall was somewhat above normal.

South Atlantic drainage:—Slight to moderate floods occurred in most of the rivers of the Atlantic slope as far north as the James River Basin. These rises resulted from moderately heavy precipitation from August 17–19 during the slow northeastward progress of the remnants of the tropical disturbance over that region. Damages were generally slight or moderate.

189871——39—3

East Gulf of Mexico drainage:—Unusually heavy rains from August 12–17, inclusive, occurred over portions of central and southern Alabama and extreme northwestern Florida. These rains accompanied the passage inland over that region on August 12–13 of a tropical disturbance which has been referred to above. The heaviest amounts occurred mainly over the lower Choctawhatchee River Basin, the Pea and Conecuh Basins and portions of the Alabama River watershed.

Geneva, Ala., and Caryville and De Funiak Springs, Fla., in the Choctawhatchee River Basin reported 19.47, 21.17, and 21.29 inches, respectively, from the 12th to the 17th, inclusive. Geneva recorded a 24 hour amount of 9.55 inches on the morning of the 13th and Caryville 10 inches on the morning of the 14th. These intense rains resulted in moderately heavy floods in the Choctawhatchee and Conecuh Rivers from August 15 to 25.

In the Alabama River Basin the heaviest rains occurred in the Cahaba and Mulberry River watersheds. At Selma, Ala., the rainfall from August 12 to 17 amounted to 16.91 inches, and 17.85 inches was recorded in the vicinity of Marion, Ala., during the same period. The intense rainfall resulted in very rapid rises in the rivers. The Cahaba River crested at 31.6 feet at Centerville, Ala., about 8.5 feet above flood stage, and greater amounts of rain fell in the Cahaba Basin below that station. The heavy discharge from the Cahaba and Mulberry Rivers combined with the rise in the Alabama proper to produce a crest stage of 53.9 feet at Selma, Ala. (flood stage, 45 feet) on August 19, and 55.2 feet on the 21st at Millers Ferry, Ala. (flood stage 40 feet). At Montgomery, Ala., the highest stage was 42.6 feet on the 18th. The previous highest stages of record for these stations are as follows: Montgomery, 57.1 feet in 1919; Selma, 56.0 feet in 1929; and Millers Ferry, 56.6 feet in 1938.

A further rise occurred in the Conecuh and Choctawhatchee Rivers on September 30 in connection with a moderate tropical storm which struck the Louisiana coast on September 26. Heavy rains fell on the 25th and 26th in the lower portions of these drainage basins with the result that the lower Choctawhatchee River reached flood stage on September 30.

A table of flood losses during August and September follows:

Table of estimated flood losses during August and September 1939

River and drainage	Tangible property	Farm property including crops	Suspension of business	Total
SOUTH ATLANTIC DRAINAGE				
Rivers in North Carolina	$350	$185,000	$10,950	$196,300
Rivers in South Carolina	3,600	500	1,000	5,100
EAST GULF OF MEXICO DRAINAGE [1]				
Apalachicola River		1,000	3,000	4,000
Conecuh River	30,750	300,150	1,200	332,100
Choctawhatchee River	20,000	510,650	400	531,050
Alabama River [2]	631,000	1,577,000	6,500	2,214,500
Missouri River Basin				
Solomon River	42,750	38,200	2,000	82,950
WEST GULF OF MEXICO DRAINAGE				
Rio Grande	5,800	1,500		7,300
Colorado River Basin				
Gila River	12,950			12,950
Total	747,200	2,614,000	25,050	3,386,250

[1] No report received for Black Warrior-Tombigbee Rivers.
[2] Preliminary estimate.

Flood-stage report for August and September, 1939

[All dates in August unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE					
James:	*Feet*			*Feet*	
Columbia, Va	10	20	21	24.7	19–20
State Farm, Va	12	20	20	15.6	20
Richmond, Va	8	20	20	9.6	20
Dan: Danville, Va	11	19	20	12.4	20
Roanoke:					
Randolph, Va	21	19	21	26.9	21
Weldon, N. C	31	20	24	[1] 40.1	22
		29	30	[1] 35.3	29
Williamston, N. C	10	25	Sept. 7	11.3	28–29
Fishing Creek: Enfield, N. C	14	29	Sept. 2	17.0	31
Tar:					
Rocky Mount, N. C	8	21	22	8.1	22
		28	Sept. 2	13.2	30
Tarboro, N. C	18	31	Sept. 6	26.5	Sept. 3
Greenville, N. C	13	30	Sept. 8	19.1	Sept. 5
Neuse:					
Neuse, N. C	14	18	24	19.9	19
		28	Sept. 2	18.8	31
Smithfield, N. C	13	19	26	19.0	21–22
		29	Sept. 4	19.2	31
Goldsboro, N. C	14	23	Sept. 8	19.1	28
Kinston, N. C	14	27	Sept. 10	16.7	31–Sept. 1
Haw: Moncure, N. C	20	19	19	23.8	19
		28	29	22.0	29
Cape Fear:					
Fayetteville, N. C	35	20	21	39.8	20
		29	30	39.8	30
Lock No. 2, Elizabethtown, N. C	20	19	23	29.0	21
		29	Sept. 2	28.6	31
Pee Dee:					
Cheraw, S. C	30	19	21	35.2	20
Mars Bluff Bridge, S. C	17	21	29	19.0	24–25
Poston, S. C	18	28	29	18.3	29
Saluda: Pelzer, S. C	6	17	21	10.8	20
Chapells, S. C	13	19	22	17.4	21
Broad: Blairs, S. C	14	19	20	18.0	20
Santee:					
Rimini, S. C	12	21	28	13.4	24
		31	Sept. 1	12.3	31
Ferguson, S. C	12	24	Sept. 1	12.5	27–28
Broad: Carlton Bridge, Ga	15	18	[2] 20	22.6	18
Savannah:					
Butler Creek, Ga	21	19	21	23.4	20–21
Clyo, Ga	11	26	Sept. 3	14.4	29
EAST GULF OF MEXICO DRAINAGE					
Apalachicola: Blountstown, Fla	15	19	30	18.7	22
Choctawhatchee:					
Newton, Ala	19	18	18	19.6	18
Geneva, Ala	23	17	21	26.7	19
Caryville, Fla	12	14	26	14.8	19
		Sept. 30	Sept. 30	12.0	Sept. 30
Conecuh:					
River Falls, Ala	35	17	22	41.0	19
Brewton, Ala	17	19	24	20.4	22
Cahaba: Centerville, Ala	23	15	18	31.6	16
Alabama:					
Montgomery, Ala	35	16	20	42.6	18
Selma, Ala	45	16	22	53.9	19
Millers Ferry, Ala	40	16	27	55.2	21
Tombigbee:					
Lock No. 3	33	16	21	39.0	18
Lock No. 1	31	20	20	31.0	20
MISSISSIPPI SYSTEM					
Missouri Basin					
Solomon: Beloit, Kans	18	15	17	27.6	16
Ohio Basin					
French Broad: Asheville, N. C	6	18	18	7.2	18
Arkansas Basin					
North Canadian; Yukon, Okla	8	13	15	8.5	15

[1] Estimated.
[2] Estimated; gage washed away on the 19th.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL in charge]

NORTH ATLANTIC OCEAN, SEPTEMBER 1939

By H. C. HUNTER

Atmospheric pressure.—Available reports from the eastern part of the North Atlantic for September are much smaller in number than usual. The information at hand indicates that the pressure over the northeastern North Atlantic averaged greater than normal. It was slightly greater than normal over the southwestern portion, but near the Azores Islands pressure was considerably less than normal, while from southern Greenland southwestward to the waters just east of the Carolinas there was a moderate deficiency.

The extremes of pressure found in vessel reports at hand were 1,034.5 and 989.5 millibars (30.55 and 29.22 inches.) The higher reading was noted within a few miles of Nantucket, on the morning of the 19th, by the American steamship *W. C. Teagle*. Table 1 shows that two land stations, Nantucket on that day and Lerwick on the 18th, recorded slightly higher pressures. The lower reading was recorded near 51° N., 23° W., shortly before noon of the 4th, by the American steamship *Schoharie*. Julianehaab had somewhat lower pressure on the 18th, also Belle Isle on the 17th.

Cyclones and gales.—The month was comparatively quiet over the North Atlantic. Three mail reports have been received of strong gales (force 9), but no report has come of any higher wind. From the 5th to the 16th there was particularly little storm activity, and after the 20th there again was very little over the main North Atlantic.

Disturbance over Gulf of Mexico.—Elsewhere in this REVIEW is an account of an unimportant disturbance noted during the latter part of the month. This moved northward over the central Gulf of Mexico and crossed the Louisiana coastline. Chart XIII presents the conditions on the 25th, and the track of the center of the disturbance.

Fog.—There was nearly everywhere less fog than during the August preceding. The decrease in frequency was marked over waters near New England and Nova Scotia and over almost all portions of the Grand Banks region. However, an increase in fog occurrence was noted near 50° N., 30° W., where the second week of the month was marked by much fog; also near the United States coast from Sandy Hook to Hatteras there was a slight increase.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, September 1939*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Julianehaab, Greenland [1]	1,005.9	−1.9	1,026	23	981	18
Lerwick, Shetland Islands						
Valencia, Ireland						
Horta, Azores	1,016.4	−5.3	1,024	11, 12	1,006	23
Belle Isle, Newfoundland [1]	1,010.4	−1.8	1,024	18	982	17
Halifax, Nova Scotia	1,016.0	−1.6	1,033	19	1,001	8
Nantucket	1,017.3	−1.3	1,035	19	1,003	8
Hatteras	1,016.8	−1.2	1,027	19	1,009	10
Turks Island	1,015.3	+0.1	1,018	6, 7, 9	1,010	20
Key West	1,014.9	+1.0	1,021	8	1,006	21
New Orleans	1,015.6	+0.4	1,021	8	1,005	26

[1] For 26 days.

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

This month the greatest number of foggy days was once more, as in August, noted in the 5° square 40° to 45° N., 65° to 70° W., where the count was 9, most of these occurring during either the first or the final weeks. There was no part of the Grand Banks region where reports show that more than 5 days had fog. Farther eastward, the square 45° to 50° N., 30° to 35° W., had fog on the 7 days, 8th to 14th, inclusive, but no days otherwise.

Compared with other years, there was practically everywhere less than average fogginess in September this year from the vicinity of Cape Cod eastward and northeastward almost to midocean.

The American steamship *Brazos* and the tug *Relief* collided during the dense fog on the 30th near Sandy Hook, and made port somewhat damaged.

OCEAN GALES AND STORMS, SEPTEMBER 1939

Vessel	Voyage		Position at time of lowest barometer		Gale began September	Time of lowest barometer. September	Gale ended September	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Millibars*					
Italia, Nor. M. S.	Port Arthur	Amsterdam	45 06 N.	38 00 W.	[1] 31	9a, 1	1	1,009.4	W	NNW, 8	NW	NNW, 8	
President Harding, Am. S. S.	New York	Cobh	44 18 N.	44 42 W.	3	8a, 3	3	994.6	NE	NE, 9	N	NE, 9	E-NNE.
Aquarius, Am. S. S.	Corpus Christi	Liverpool	46 00 N.	38 30 W.	3	6p, 3	4	999.0	SSE	NNE, 9	N	NNE, 9	SSE-NNE.
West Ira, Am. S. S.	Barbados	Rio de Janeiro	6 50 N.	47 43 W.	7	Mdt, 7	8	1,012.9	ENE	ENE, 6	SE	ENE, 6	SE-ENE-SE.
Arundo, Du, S. S.	Rotterdam	Baltimore	46 03 N.	40 54 W.	10	Noon, 10	10	[2] 1,003.9		S, 8		S, 8	
Scanyork, Am. S. S.	Copenhagen	New York	57 54 N.	26 48 W.	11	10a, 11	11	1,008.1	S	S, 8	WSW	S, 8	S-SW.
Wacosta, Am. S. S.	Glasgow	do	[3] 44 15 N.	57 53 W.	18	4a, 17	18	1,001.0	NW	WSW, 6	NE	N, 9	SW-WSW-SW.
American Merchant Am. S. S.	London	do	48 36 N.	48 42 W.	17	9a, 17	17	996.6		S, 8		S, 8	
Colytto, Du. S. S.	Swansea	Baltimore	51 18 N.	34 24 W.	20	10a, 20	20	1,002.2		SE, 8		SE, 8	
Aztec, Am. S. S.	Minatitlan	Tuxpam	18 42 N.	94 30 W.	22	6p, 22	24	1,008.8		WNW, 8	WNW	WNW, 8	
Jean Lafitte, Am. S. S.	Glasgow	New York	49 00 N.	40 36 W.	25	4p, 25	26	999.7	SE	WNW, 8	WNW	WNW, 8	SE-WNW.
Roanoke, Am. S. S.	Savannah	Port Arthur	27 54 N.	89 00 W.		6a, 26		1,010.2		SSW, 7		SSW, 7	SSW-SW.
NORTH PACIFIC OCEAN													
Nankai Maru, Jap. M. S.	Yokohama	Los Angeles	41 25 N.	138 35 W.	[1] 31	4a, 1	1	1,027.8	NNE	NNE, 8	NNE	NNE, 8	
Guide, U. S. C. & G. S.	Dutch Harbor to near.	Unimak Island	54 36 N.	164 42 W.	2	1a, 2	2	1,011.9	S	SW, 2	W	SW, 8	SW-S-W.
La Placentia, Am. S. S.	Los Angeles	Vancouver, B. C.	41 30 N.	124 45 W.	2	6p, 2	2	1,013.9	NNW	NNW, 8	NNW	NNW, 8	None.
Anniston City, Am. S. S.	Balboa	Honolulu	21 12 N.	150 12 W.	3	2p, 3	4	1,015.9		N, 7	NE	N, 7	

See footnotes at end of table.

OCEAN GALES AND STORMS, SEPTEMBER 1939—Continued

Vessel	Voyage		Position at time of lowest barometer		Gale began September	Time of lowest barometer. September	Gale ended September	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH PACIFIC OCEAN—Continued			° ′	° ′				*Millibars*					
Makaweli, Am. S. S.	Hilo, T. H.	San Francisco	22 34 N.	151 13 W.	3	4p, 3	4	1,015.9	ENE.	E, 9	ENE.	E, 9	ENE-ESE.
Potter, Am. M. S.	Los Angeles	Balboa	16 59 N.	101 47 W.	5	3a, 6	6	1,008.5	ESE.	E, 8	ESE.	E, 8	
San Gabriel, Am. S. S.	do	do	17 59 N.	103 26 W.	6	5p, 6	7	1,005.4	E.	E, 8	SE.	E, 9	
Charles H. Cramp, Am. S. S.	do	do	13 55 N.	95 00 W.	7	5p, 7	7	1,004.4	NE.	SE, 8	SSE.	SE, 9	E-SSE.
Potter, Am. M. S.	do	do	13 58 N.	95 24 W.	7	9p, 7	7	1,004.1	ENE.	SE, 9	S.	SE, 9	E-SE.
Panaman, Am. S. S.	do	do	19 18 N.	106 11 W.	7	6a, 7	8	1,001.4	NE.	E, 12	E.	E, 12	NE-E.
Kainalu, Am. S. S.	do	do	18 32 N.	107 15 W.	7	11a, 7	8	995.6	N.	WNW, 12	S.	WNW, 12	N-SW.
Vega, U. S. N.	San Diego	do	14 12 N.	93 55 W.	7	6p, 7	8	1,008.8	S.	S, 7	S.	S, 7	
Horace Luckenbach, Am. S. S.	Balboa	Los Angeles	20 59 N.	107 51 W.	7	11p, 7	8	989.2	ESE.	E, 12	SSE.	E, 12	E-SSE.
West Cactus, Am. S. S.	do	do	21 53 N.	109 53 W.	7	5a, 8	8	986.1	N.	NW, 12	SW.	NW, 12	NE-NW-SW.
Point Judith, Am. S. S.	do	do	[2]21 21 N.	108 50 W.	7	2a, 8	8	[2]948.2	ENE.	Var. 4	SW.	NNE, 12	NNE-WSW.
Losmar, Am. S. S.	Los Angeles	Balboa	22 40 N.	110 10 W.	8	1p, 8		958.3	NE.	—, 12		—, 12	
Horace Luckenbach, Am. S. S.	Balboa	Los Angeles	23 48 N.	111 55 W.	8	9p, 8	9	986.1	S.	SE, 12	SE.	SE, 12	ESE-SE.
Minnesotan, Am. S. S.	do	do	23 50 N.	111 55 W.	7	10p, 8	9	982.4	ESE.	SE, 12	S.	SE, 12	ESE-S.
J. L. Luckenbach, Am. S. S.	Los Angeles	Balboa	24 00 N.	112 30 W.	8	—a, 9	9					Shifting, 11	
San Gabriel, Am. S. S.	do	do	15 45 N.	97 48 W.	8	2a, 9	9	1,010.5	E.	E, 9	SE.	E, 9	E-ESE.
Maui, Am. S. S.	do	do	25 24 N.	113 35 W.	9	Noon, 9	9	1,003.1	NNE.	SE, 8	SE.	SE, 8	NNE-SE.
Hamakua, Am. S. S.	do	do	27 00 N.	114 36 W.	9	4p, 9	10	1,006.8	ESE.	ESE, 2	E.	ESE, 8	
Texas, Am. S. S.	do	Yokohama	46 00 N.	176 52 E.	8	2a, 10	11	993.9	NE.	SSW, 9	NW.	SSW, 10	SSW-WSW.
Guide, U. S. C. & G. S.	Dutch Harbor	Unimak Island.	55 06 N.	164 42 W.	10	10a, 11	11	1,017.3	S.	S, 8	S.	SE, 8	S-SSW-SE.
Discoverer, U. S. C. & G. S.	On survey work near.	Aleutian Islands.	54 30 N.	162 36 W.	14	Noon, 14	15	1,012.5	NW.	NW, 7	NW.	NW, 10	W-NW.
Vermont, Am. S. S.	Los Angeles	Balboa	22 57 N.	118 18 W.	13	4a, 14	14	1,007.5	NW.	WSW, 8	SW.	W, 8	WNW-SW.
Henry S. Grove, Am. S. S.	do	do	[2]13 37 N.	94 24 W.	14	8a, 15	15	1,008.1	SE.	NE, 6	ESE.	NE, 7	NE-E.
Hamakua, Am. S. S.	do	do	[2]14 14 N.	94 29 W.	15	4p, 16	17	1,006.8	NE.	ESE, 7	E.	E, 7	ENE-SE.
City of Los Angeles, Am. S. S.	do	do	15 08 N.	96 33 W.	17	2p, 17	17	1,007.1	ESE.	ENE, —.	SE.	ESE, 7	
Manoeran, Du. M. S.	San Francisco	do	17 25 N.	106 20 W.	18	4p, 19	20	1,007.2	NW.	ESE, 5	W.	E, 7	ENE-ESE.
Besholt, Nor. M. S.	Los Angeles	do	18 00 N.	113 36 W.	20	11p, 20	21	983.9	NE.	NNW, 9	S.	NNW, 10	NE-NNW.
Canton, Swed. M. S.	Manila	San Francisco	41 08 N.	149 35 W.	20	7a, 20	20	980.5	SW.	E, 10	SW.	SE, 11	SW-E-SE.
Kansai Maru, Jap. M. S.	Yokohama	Los Angeles	[2]46 43 N.	166 09 W.	22	6a, 23	23	977.3	NW.	SSE, 7	SSW.	N, 8	SE-SSW.
Chirikof, Am. S. S.	Chignik, Alaska.	San Francisco	55 32 N.	156 18 W.	23	6p, 23	23	993.2	ENE.	E, 7	E.	E, 9	E-SE.
Discoverer, U. S. C. & G. S.	On survey work near.	Aleutian Islands.	[2]54 44 N.	162 56 W.	23	4p, 23	23	987.5	ENE.	E, 8	E.	E, 11	E-SE.
Leonard Wood, U. S. A. T.	Balboa	San Francisco	31 48 N.	118 48 W.	24	4p, 24	24	1,001.4		S, 8		S, 8	
San Clemente Maru, Jap. M. S.	Los Angeles	Yokohama	38 45 N.	145 00 E.	23	2a, 24	24	984.1	ENE.	NE, 6	NW.	NW, 8	ENE-NNW.
Bengal Maru, Jap. S. S.	do	Balboa	32 55 N.	117 45 W.	24	5a, 25	25	[2]993.2	SSE.	SE, 9	SW.	SE, 9	SE-SSW.
Akiura Maru, Jap. M. S.	Kamchatka	Los Angeles	50 44 N.	160 00 E.	24	4p, 25	26	990.2	ENE.	NNE, 8	NNW.	NNE, 8	ENE-N.
Sawokla, Am. S. S.	Masinloc, P. I.	do	42 40 N.	172 25 E.	25	Mdt, 25	26	999.3	SSW.	SW, 7	WNW.	W, 8	SSW-WSW.
Sanyo Maru, Jap. M. S.	Yokohama	San Francisco	45 33 N.	167 17 E.	24	Mdt, 25	26	991.9	SSE.	WSW, 8	NW.	WNW, 9	WSW-WNW.
Kiyo Maru, Jap. M. S.	Nagaroki	Los Angeles	[2]46 29 N.	177 43 W.	26	5p, 25	27	997.8	W.	SW, 6	WNW.	W, 8	S-WSW.
Guide, U. S. C. & G. S.	Dutch Harbor	Seattle	54 54 N.	163 24 W.	26	2p, 27	27	982.7	SE.	S, 2	SE.	SE, 9	SSE-SW.
Azuma Maru, Jap. M. S.	Yokohama	San Francisco	47 12 N.	178 06 W.	27	Noon, 26	27	1,007.2		NW, 8	WNW.	NW, 8	
Discoverer, U. S. C. & G. S.	On survey work near.	Aleutian Islands.	54 30 N.	162 18 W.	26	2a, 28	27	988.2	SE.	SW, 4	SE.	SE, 10	

[1] August.
[2] Barometer uncorrected.
[3] Position approximate.

NORTH PACIFIC OCEAN, SEPTEMBER 1939

By WILLIS E. HURD

Atmospheric pressure.—On the average, a long, shallow LOW, pressure 1,008.0 to 1,010.3 millibars (29.77 to 29.83 inches), extended from the Gulf of Alaska across Aleutian waters and the southeastern part of the Bering Sea. The lowest daily pressure of the month at any of the island stations in this region was 979 millibars (28.91 inches), at Kodiak, on the 6th; the highest pressure was 1,032 millibars (30.48 inches), at St. Paul Island, in the Bering Sea, on the 15th. Throughout the Aleutian region the average barometer was higher than the normal, that at St. Paul, 1,010.3 millibars, being 4.2 millibars (0.12 inch) above. In middle latitudes, on the eastern half of the ocean, high pressure was strongly developed from the 1st to the 17th, but was thereafter broken by intruding LOWS. Here the average pressure was near normal. In the southwestern Tropics, following the extraordinarily depressed conditions of August, pressure had risen, and was for the most part above normal in September.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, September 1939, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Point Barrow	1,010.2	−2.3	1,023	22	995	16
Dutch Harbor	1,008.8	+1.0	1,029	15	981	27
St. Paul	1,010.3	+4.2	1,032	15	987	26
Kodiak	1,008.0	+1.9	1,023	10	979	6
Juneau	1,013.5	+0.3	1,030	23	990	15
Tatoosh Island	1,017.7	+0.8	1,026	18	1,006	12
San Francisco	1,013.9	0.0	1,022	14	1,005	25
Mazatlan	1,010.2	+0.4	1,013	3, 4, 24	1,006	27
Honolulu	1,014.8	−1.1	1,018	3	1,011	28
Midway Island	1,016.9	+0.6	1,023	4	1,009	11
Guam	1,009.4	−0.8	1,012	2, 6	1,004	18
Manila	1,009.3	+1.2	1,013	6	1,006	16
Hong Kong	1,009.1	+1.0	1,013	30	1,003	1
Naha	1,010.5	+2.7	1,016	24–25, 30	1,006	8
Titijima	1,011.7	+0.5	1,016	14–15, 25–26	1,006	10
Petropavlovsk [1]			1,020	18	999	24

[1] For 16 days.

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Extratropical cyclones and gales.—The centers of most extratropical cyclones of the month moved in high latitudes, crossing the Aleutians or the Bering Sea from west to east, but affecting the weather far to the southward along the upper main traveled routes. A few cyclones of importance, however, formed in middle latitudes. While storminess had increased considerably, since the preceding month, it was severe only locally, according to reports received; near 46° N., 177° E., on the 9th, force 10; to the near southward of the Alaska Peninsula and the eastern Aleutians on the 14th, 23d, and 26th, force 10–11; and near 41° N., 150° W., on the 20th, force 11.

Prior to the 15th the only winds reported as high as force 8, aside from the stronger winds mentioned as of the 9th and 14th, occurred close to the center of the high pressure area near 41° N., 139° W., on the 1st; off the coast of northern California on the 2d; and near the tip of the Alaska Peninsula on the 2d and 11th.

During the 15th and 16th a LOW traversed the Gulf of Alaska and the adjacent waters of the ocean, causing northerly winds of force 7–8 in the gulf on the 15th.

A depression left the northern California coast on September 25–26 and, after an unusual southwestward course to about 32° N., 135° W., went northward and dissipated on the 28th. The strongest wind noted in connection with the disturbance was of force 7, near 40° N., 129° W.

From the 17th to 23d an extensive cyclone lay over midocean. It moved slowly in an east-to-northeast direction until the 22d, then with much increased rapidity northward toward the Alaskan coast. The cyclone attained considerable intensity on the 20th, as shown by the report of the Swedish motorship *Canton*, San Francisco toward Manila. This ship encountered a gale of force 11 at local noon, in 41°08′ N., 149°35′ W., and had a low barometer reading of 980.5 millibars (28.96 inches) 5 hours earlier. The Japanese motorship *Kansai Maru* reported a lower barometer, 977.3 millibars (28.86 inches), near 47° N., 166° W., on the 23d, but this ship met only winds of force 7–8. At noon of the 23d the United States Coast and Geodetic Survey Ship *Discoverer* encountered a force-11 gale from the east, barometer 987.5 millibars (29.16 inches), near 55° N., 163° W.

On the 24th a further cyclone lay near northern Japan. In its eastward course, it crossed the western Aleutians on the 25th–26th. The center skirted the islands to the northward and entered southwestern Alaska from the Bering Sea on the 29th. Stormy weather was reported by several ships along the northern routes during its course from the 24th to 27th. The earliest gale reported was of force 8, met by the Japanese motorship *San Clemente Maru*, barometer 984.1 millibars (29.06 inches), not far from the east coast of Honshu Island. The succeeding gale reported, also of force 8, occurred on the 25th, southeast of Kamchatka. On the 26th westerly gales of force 8 to 9 occurred within the area 42°–47° N., 172° E.–177° W., and a southeast gale of force 11, barometer 980 millibars (28.94 inches) was reported by radio from a ship in a position southwest of Dutch Harbor. Late on the 26th the United States Coast and Geodetic Survey ships *Guide* and *Discoverer* encountered southeast gales of force 9 and 10, respectively, to the eastward of Dutch Harbor. On the 27th the storm had lessened in energy, and the highest winds reported for the day were of force 8, south of the central Aleutians.

Cyclones and gales of the Tropics.—In tropical waters of the North Pacific there was much less storm activity in the southwestern part of the ocean, and much more in the southeastern, than in the preceding month. An account of the typhoons and depressions over the Far East for September 1939, prepared by the Rev. Bernard F. Doucette, S. J., Weather Bureau, Manila, P. I., is subjoined.

Reports from two ships to the east of the Hawaiian Islands on September 3 indicate the existence of a disturbed condition in the afternoon. The American steamer *Anniston City* had a north wind of force 7 in 21°12′ N., 150°12′ W., at 2 p. m., and the American steamer *Makaweli* encountered an east gale of force 9, in 22°34′ N., 151°13′ W. at 4 p. m. The lowest barometer reported by both vessels was 1,015.9 millibars (30 inches).

In Mexican waters three cyclones passed up the coast in a general northwesterly direction. Two were of hurricane or near hurricane intensity, one being particularly violent over and in the vicinity of the mouth of the Gulf of California, and the other being of unique economic importance to southern California, besides being the first tropical storm of this severity to have affected this coast within our years of record. These storms will be made the subject of a special article to appear in a later issue of the REVIEW, and will therefore receive only brief treatment in the present report.

The first, that of September 5–12, had its origin to the southward of Acapulco and its dissipation over the upper part of Lower California. It was of great severity on the 7th to 9th, with hurricane winds reported by several ships from positions south of Cape Corrientes and thence for some distance northward up the southern west coast of Lower California. The American steamer *Point Judith*, during the early morning hours of the 8th, passed through the hurricane center, near 21° N., 109° W., with light variable winds, and a barometer reading of 948.2 millibars (28 inches), the lowest point on the aneroid's scale. Hurricane winds were experienced by this ship before and after passage of the center.

The second cyclone, that of the 5th to 14th, originated near 9° N., 88° W., or at some distance off the coast of southern Costa Rica, and dissipated over the southern headlands of Lower California. The highest wind reported for this cyclone was of force 9, experienced by the American vessels *Potter* and *Charles H. Cramp* on the 7th, near 14° N., 95° W., and by the steamer *San Gabriel* on the 9th, near 16° N., 98° W. The lowest barometer reported was 1004.1 millibars (29.65 inches), read on the motorship *Potter* on the 7th.

The third cyclone, that of the 14th to 25th, originated near 10° N., 91° W., moved in a west-northwesterly direction, and after describing a wide curve to the southward and westward of the Revillagigedo Islands, went north then northeast and its center entered southern California near Los Angeles early on the 25th. A number of ships reported moderate gales (force 7) from the 15th to 19th, but the highest wind velocity and lowest barometer yet reported by a ship were contained in a radio message received from the American steamer *Ewa*, Balboa toward Honolulu, on the 22d. This ship was close to the storm center at 7 a. m. (E. S. T.) of that date, near 21° N., 116° W., where she encountered a southeast gale of force 11, barometer 971 millibars (28.67 inches). As the storm neared the southern California coast during the late afternoon on the 24th and early morning of the 25th, ships in coastal vicinities reported southeasterly gales of force 8 to 9.

The severity of the storm along the coast is indicated by a loss of 45 lives at sea, and a property damage approximating $2,000,000, mostly to shipping, shore structures, power and communication lines, and to crops. Unprecedented September rains accompanied the storm along the southern California coast.

Fog.—Fog occurrence in September changed but little from that of the preceding month over the eastern part of the northern routes, but lessened materially over the western part. The most frequent open ocean fogs occurred between about latitudes 45° and 50° N., longitudes 150° to 175° W., with about 7 to 10 days with fog reported in each included 5° square. East of 155° W., fog occurred on 1 to 4 days between the 50th parallel and the Gulf of Alaska. Along the immediate American coast, 14 days were reported with fog off Washington; 7 off Oregon; 11 off California; and 3 off Lower California.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST, SEPTEMBER 1939

By BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Depression, September 12–16, 1939.—A depression, apparently of minor importance, formed about 300 miles south of Guam, moved northwest, then west-northwest and disappeared about 600 miles east-northeast of San Bernardino Strait.

Typhoon, September 17–19, 1939.—This disturbance formed over the China Sea somewhere southeast of the Paracel Reefs and seems to have moved in a northwesterly direction toward the southwestern part of Tong King Gulf. It probably was weak in the beginning of its progress and intensified as it approached the continent. Because of the war situation, there were no ship's observations available and its approach to the coast of Indochina, with typhoon intensity, was known only from a special typhoon warning broadcasted from Phulien. It entered Indochina about 150 miles northwest of Tourane.

Typhoon, September 18–24, 1939.—Forming as a depression about 250 miles west of Guam, this storm moved west-northwest and northwest to the ocean regions about 600 miles east of Aparri, reaching this position on the morning of September 21, already intensified to typhoon strength. It recurved to the northeast during the forenoon hours of the same day and continued along this course to the regions east of northern Japan, after moving almost parallel and quite close to the coast line of that country. No trace of the typhoon could be found on September 25.

The upper winds at Guam were from the southwest quadrant beginning September 16, weak at first, and then increasing to values over 50 kilometers per hour (the highest being 64 kilometers per hour, at the morning ascent of September 19). This current began to weaken after September 20. During these days when the depression was forming, southern Phillippine stations and Menado, Celebes Island, had winds from the northwest and northeast quadrants mostly, with southwest winds only at isolated levels. The velocities hardly ever reached 40 kilometers per hour and were below 20 kilometers per hour most of the time. At the same time strong southwest and west winds were reported from Thailand, due to the China Sea typhoon of September 17 to 19, mentioned above. The distribution of upper winds, as outlined above, indicates that the air in the southwestern sector of this typhoon (in the Pacific) was attracted toward the center of the disturbance rather than forced toward the center from remote regions.

Typhoon, September 27–October 1, 1939.—Pressure was relatively low over the China Sea after September 26, with some indications of circulation. No definite center appeared, however, until September 29, when it seemed certain that there was a depression or typhoon central near Maccles Field Reefs. This disturbance moved west-northwest, intensified, and entered the continent close to and south of Tourane on September 30. Only slight traces of the typhoon could be found on the weather maps of October 1.

The Paracel Island station reported pressure of 750 mm. (999.9 mb.) at 2 p. m. September 29 (Manila time) with east-northeast winds, force 5. Tourane, the afternoon of the following day, had north-northwest winds, force 9, with pressure at 751.8 mm. (1,002.3 mb.).

During the formation and course of this typhoon, Hong Kong had upper winds from the east quadrant, with velocities as high as 85 kilometers per hour (the morning ascent of September 30). Thailand stations had southwest quadrant winds predominating, with velocities often above 50 kilometers per hour, the maximum value being 110 kilometers per hour (from Bandon, morning ascent of September 30).

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, September 1939*

[For description of tables and charts, see REVIEW, January, p. 31]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	77.3	+1.6	Tuscumbia	101	14	2 stations	50	[1] 22	3.92	+0.40	Brewton	12.28	Valley Head	0.31
Arizona	72.1	−.7	3 stations	114	1	Springerville	27	28	3.82	+2.52	Bright Angel R. S.	12.31	Miami	.27
Arkansas	79.9	+5.4	Booneville	112	4	Lead Hill	35	30	1.77	−1.57	Lutherville	5.43	Grannis	.11
California	69.1	+1.4	El Centro	115	1	Tamarack	14	14	1.70	+1.23	Mount Wilson	11.78	2 stations	.00
Colorado	61.6	+3.6	3 stations	104	[1] 5	Pearl	16	30	1.10	−.25	Wolk Creek Pass	4.62	Long Branch	T
Florida	80.3	+.9	Avon Park	101	8	Mason	57	23	5.79	−.90	Fort Myers	12.83	Monticello	1.94
Georgia	76.9	+1.4	Athens No. 2	103	10	Blairsville	41	22	2.88	−.78	Monticello	8.00	Clayton	.75
Idaho	58.5	+1.4	Lewiston	102	20	Obsidian (near)	18	29	.97	−.06	Grimes Pass	2.58	2 stations	T
Illinois	72.4	+4.5	2 stations	106	[1] 8	Sycamore	31	30	.74	−2.97	Mascoutah	3.02	Bloomington	.03
Indiana	72.0	+4.7	do	107	[1] 8	La Porte	28	30	.84	−2.52	Marengo	2.81	Monticello	.09
Iowa	69.3	+5.4	do	107	[1] 6	Sibley	16	30	.82	−3.02	Fayette	1.78	Melrose	.17
Kansas	75.5	+5.7	Sedan	113	2	Burr Oak	24	30	.32	−2.45	Centralia	1.50	7 stations	.00
Kentucky	74.5	+3.9	Princeton	105	[1] 8	Taylorsville	39	23	1.26	−1.67	Maysville	5.09	Owensboro Dam No. 46	.22
Louisiana	79.9	+1.9	Minden	105	4	Winnfield	49	25	3.23	−.62	Port Sulphur	14.57	Robeline	.26
Maryland-Delaware	69.2	+1.5	2 stations	100	8	Oakland, Md	31	23	3.02	−.15	Washington, D. C.	6.90	Delaware City, Del	.54
Michigan	61.6	+1.9	Monroe	103	16	Roscommon	19	24	2.63	−.68	Deer Park (near)	4.95	New Buffalo	.42
Minnesota	63.4	+4.2	Redwood Falls	103	14	Grand Rapids	15	26	1.42	−1.42	Gonvick	6.63	Wadena	.30
Mississippi	78.9	+2.9	3 stations	103	[1] 9	Rochdale	48	23	3.09	+.05	Merrill	9.82	Corinth	.61
Missouri	75.5	+6.1	do	108	[1] 2	2 stations	30	30	.81	−3.23	Doniphan	3.65	Steffenville	.12
Montana	57.6	+2.4	Ingomar (near)	100	1	Outlook	9	29	.94	−.39	Babb (near)	3.78	Ingomar (near)	.13
Nebraska	69.6	+5.2	Agronomy Farm (Lincoln).	110	7	Gordon	22	30	.44	−1.60	Harrison	1.19	Friend	T
Nevada	62.9	+1.7	Overton	109	1	2 stations	19	15	1.34	+.94	Searchlight	8.45	San Jacinto	.13
New England	59.7	−.5	Fitchburg, Mass	99	16	Fort Kent, Maine	22	27	2.85	−.98	York Pond, N. H.	5.83	Rockport, Mass	.88
New Jersey	66.5	+.6	Phillipsburg	98	8	2 stations	31	[1] 18	1.48	−2.08	Dover	2.74	Indian Mills	.53
New Mexico	66.2	+1.8	Hobbs	109	3	Eagle Nest	17	30	1.83	+.14	Winsor's	4.68	Loving	.00
New York	62.1	−.9	Geneva	100	16	Indian Lake	21	22	3.20	−.29	Knapp Creek	6.78	Patchogne	.65
North Carolina	72.8	+1.8	3 stations	104	[1] 9	Banners Elk	33	22	1.45	−2.53	Fayetteville	3.63	Mount Airy	.00
North Dakota	58.9	+2.1	5 stations	98	[1] 1	Center	11	25	.68	−.83	Mayville	3.08	2 stations	.00
Ohio	70.1	+4.4	Van Wert	105	[1] 14	2 stations	32	22	2.08	−.90	Canfield	4.64	Chilo	.28
Oklahoma	80.0	+5.7	Alva	115	3	3 stations	33	30	.33	−2.76	Smithville	3.52	18 stations	.00
Oregon	59.9	+2.1	Powers	103	19	Chemult	11	7	.64	−.54	Round Grove	1.98	Hood River	.01
Pennsylvania	65.9	+1.7	Chambersburg	101	8	Gouldsboro	27	[1] 18	2.95	−.44	Coudersport	6.27	George School	.70
South Carolina	76.3	+1.8	Little Mountain	106	9	Long Creek (near)	48	22	2.18	−1.96	Columbia	6.06	Cherokee (near)	.28
South Dakota	65.5	+3.9	Armour	109	6	Aberdeen	11	29	1.02	−.49	Leola	3.24	Ludlow	.10
Tennessee	75.3	+3.7	Clarksville	106	14	4 stations	43	[1] 12	1.36	−1.67	Crossville	4.27	Johnsonville	.50
Texas	79.6	+2.3	Cleburne	114	2	Levelland	35	30	1.12	−1.77	Yoakum	6.05	27 stations	.00
Utah	61.8	+1.1	2 stations	101	1	Woodruff	19	30	2.61	+1.58	Bryce Canyon	8.83	Callao	.29
Virginia	70.4	+1.7	do	101	8	Burkes Garden	33	23	1.16	−1.95	Washington, D. C.	6.90	Rocky Mount	.05
Washington	60.3	+2.1	Lacrosse (near)	101	20	Deer Park (near)	23	29	.84	−.99	Quinault	5.95	4 stations	T
West Virginia	68.8	+2.3	Ravenswood	103	10	Seneca State Forest	29	[1] 18	2.22	−.68	Brandywine	5.22	Union	.33
Wisconsin	62.5	+2.1	Prairie du Chien	104	7	Prentice	17	26	2.64	−1.05	Menasha	5.45	Ashland	.36
Wyoming	56.8	+2.1	Yoder	100	2	Big Piney	14	29	.92	−.21	Dixon	2.28	Marshall (near)	.20
Alaska (August)	51.5	−1.2	Bell Island	88	8	2 stations	26	[1] 24	5.40	+2.03	Deordova	32.35	2 stations	.37
Hawaii	72.4	−.6	Mahukona	93	6	Kanalohuluhulu	50	[1] 1	4.36	−1.65	Kukui (Maui)	23.00	Mahukona	.00
Puerto Rico	79.0	+.5	Pattillas Dam	99	[1] 19	Garzas	58	[1] 16	6.62	−1.80	Rio Blanco (1800)	17.42	Central San Francisco.	1.85

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau Stations, September 1939*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F*		*° F*	*° F*		*° F*	*° F.*	*° F.*	*° F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							**61.5**	**+0.7**										**80**	**2.01**	**−1.1**										**5.3**		
Eastport	75	67	85	29.91	29.99	−0.04	56.3	+0.5	91	16	64	38	27	49	37	52	50	85	1.53	−1.2	11	9.0	sw.	26	sw.	23	6	6	18	6.9	0.0	0.0
Greenville, Maine	1,069	4	41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.25	−1.2	9	5.3	n.	19	nw.	7	11	10	9	5.1	.0	.0
Portland, Maine	103	82	117	29.89	30.01	−.04	60.2	+.6	96	16	68	37	27	52	35	54	50	76	1.62	−1.5	10	7.9	s.	34	s.	10	11	13	6	4.4	.0	.0
Concord	288	54	72	29.72	30.03	−.03	60.6	+1.3	95	16	73	34	27	48	37	.....	.....	.....	2.25	−1.2	9	5.3	n.	19	nw.	7	11	10	9	5.1	.0	.0
Burlington	403	11	48	29.57	29.99	−.07	59.2	−1.1	92	16	70	31	27	49	34	53	49	74	3.77	+.3	13	8.6	s.	31	s.	25	9	9	12	5.7	T	.0
Northfield	876	12	60	29.08	30.03	−.03	56.2	+.1	93	15	70	24	27	42	42	51	48	82	2.53	−.5	11	7.2	sw.	28	s.	25	6	12	12	6.1	T	.0
Boston	29	33	62	29.99	30.02	−.05	64.5	+1.3	96	16	73	45	27	56	28	58	54	74	1.01	−2.1	7	10.8	sw.	34	sw.	25	10	8	12	5.2	.0	.0
Nantucket	12	14	90	30.03	30.04	−.04	63.0	+.2	77	3	69	47	19	57	19	59	57	85	1.08	−1.4	9	14.0	sw.	35	n.	17	12	7	11	5.0	.0	.0
Block Island	26	11	46	30.02	30.05	−.03	63.6	+.2	77	3	69	50	27	58	21	60	58	83	.92	−1.7	6	14.2	s.	33	sw.	16	15	6	9	4.0	.0	.0
Providence	159	215	251	29.98	30.05	−.02	64.2	+1.0	91	16	74	44	27	55	28	58	56	82	2.39	−.8	9	10.4	sw.	30	nw.	10	15	2	13	4.8	.0	.0
Hartford	159	66	100	29.99	30.03	−.04	63.8	+2.1	90	16	74	41	27	54	41	57	55	83	2.73	−.8	7	7.8	s.	25	nw.	11	10	9	11	5.6	.0	.0
New Haven	106	74	153	30.04	30.05	−.02	64.6	+1.1	87	16	73	44	27	56	26	59	56	80	2.33	−1.2	10	8.4	s.	25	nw.	10	12	8	10	5.1	.0	.0
Middle Atlantic States							**68.7**	**+1.8**										**77**	**2.32**	**−0.9**										**5.1**		
Albany	292	26	40	29.70	30.02	−.05	61.7	−1.4	92	16	74	33	22	50	39	56	52	77	3.61	+.5	9	8.7	s.	33	s.	25	8	12	10	5.7	.0	.0
Binghamton	871	57	79	29.13	30.05	−.02	64.4	+3.1	96	16	77	35	22	52	40	56	52	74	4.65	+1.6	13	5.8	e.	24	nw.	10	4	13	13	6.6	.0	.0
New York	314	415	454	29.71	30.04	−.04	67.4	+.6	88	8	76	50	27	59	23	60	56	74	1.21	−2.2	10	12.9	sw.	40	nw.	17	12	9	9	4.7	.0	.0
Harrisburg	351	30	49	29.68	30.05	−.03	68.0	+2.2	99	8	79	42	19	57	39	60	57	76	3.43	+.4	10	6.9	se.	23	s.	25	11	7	12	5.7	.0	.0
Philadelphia	114	174	367	29.93	30.06	−.02	69.2	+1.2	96	8	78	52	18	61	30	62	59	77	1.91	−1.2	8	11.2	sw.	31	n.	17	10	14	6	4.8	.0	.0
Reading	323	283	306	29.71	30.06	.....	67.0	+.7	96	8	76	44	19	58	33	60	56	73	2.55	−.7	9	9.1	s.	32	n.	17	13	7	10	5.2	.0	.0
Scranton	805	72	104	29.19	30.04	−.03	64.2	+1.3	91	8	76	38	19	53	36	56	52	73	2.92	−.2	11	5.9	sw.	34	nw.	10	8	14	8	5.2	.0	.0
Atlantic City	52	37	172	29.99	30.05	−.02	68.6	+1.8	94	8	75	52	18	62	27	64	61	79	1.50	−1.2	7	13.4	s.	39	se.	27	8	15	7	5.0	.0	.0
Sandy Hook	22	10	57	30.02	30.04	.....	67.6	+.1	88	8	74	53	18	61	22	62	59	78	1.27	−2.2	8	12.7	s.	40	ne.	8	12	11	7	4.5	.0	.0
Trenton	190	89	107	29.85	30.05	.....	67.2	+.3	95	8	77	45	19	57	31	61	57	78	1.48	−1.9	6	7.7	s.	23	n.	17	11	9	10	5.2	.0	.0
Baltimore	123	100	215	30.04	30.05	−.03	71.2	+2.7	100	8	80	54	18	63	31	63	61	80	3.08	−.3	8	9.2	s.	30	sw.	4	11	11	8	4.9	.0	.0
Washington	112	62	85	29.93	30.05	−.03	71.0	+2.9	100	8	80	51	18	62	28	63	61	78	6.90	+3.7	6	5.5	s.	26	ne.	4	11	11	8	5.0	.0	.0
Cape Henry	18	8	54	30.02	30.04	.....	73.8	+2.0	97	8	80	56	23	68	25	68	66	81	1.06	−1.8	4	10.7	ne.	33	ne.	17	13	11	6	4.6	.0	.0
Lynchburg	686	144	184	29.34	30.07	−.01	72.0	+3.0	97	8	84	48	19	60	32	64	61	78	1.21	−2.1	8	5.3	n.	24	nw.	4	15	8	7	4.0	.0	.0
Norfolk	91	80	125	29.96	30.06	.00	74.8	+3.2	96	8	82	60	23	68	22	68	65	78	.56	−2.7	3	8.2	e.	24	ne.	18	8	11	11	6.0	.0	.0
Richmond	144	11	52	29.88	30.05	−.02	72.8	+2.3	96	8	83	53	18	63	28	65	63	87	1.56	−1.7	7	6.4	sw.	28	nw.	17	14	11	5	4.0	.0	.0
Wytheville	2,304	49	55	27.72	30.09	+.02	67.4	+3.8	92	9	81	43	22	54	39	59	56	75	.68	−2.6	4	5.2	w.	18	w.	8	18	9	3	3.2	.0	.0
South Atlantic States							**76.9**	**+3.6**										**80**	**2.82**	**−1.4**										**5.0**		
Asheville	2,283	89	104	27.79	30.10	+.03	69.9	+4.9	93	9	82	48	22	57	33	61	59	81	1.61	−1.4	8	5.6	nw.	24	e.	18	13	10	7	5.0	.0	.0
Charlotte	779	63	86	29.24	30.05	−.02	75.7	+4.2	101	9	86	57	23	65	30	65	62	77	1.56	−1.4	5	6.2	ne.	23	ne.	13	14	10	6	4.6	.0	.0
Greensboro	886	6	56	29.14	30.07	.....	72.8	.....	99	9	85	50	23	60	33	64	62	81	.13	.....	5	6.7	ne.	34	nw.	4	14	9	7	4.3	.0	.0
Hatteras	11	8	50	30.02	30.03	−.03	76.2	+1.7	91	8	81	66	13	71	16	71	69	82	2.52	−2.1	8	11.2	ne.	31	se.	27	9	11	10	5.6	.0	.0
Raleigh	376	103	146	29.67	30.05	−.02	74.8	+3.7	99	9	84	56	19	65	24	67	65	83	2.35	−1.3	6	7.7	ne.	20	n.	17	12	15	3	4.3	.0	.0
Wilmington	72	73	107	29.95	30.03	−.02	76.4	+3.3	98	9	84	58	23	68	26	70	69	86	2.67	−1.8	9	7.3	ne.	24	n.	17	7	13	10	5.9	.0	.0
Charleston	48	11	92	29.97	30.02	−.02	79.2	+2.6	97	9	85	65	22	73	20	71	70	88	1.16	−3.4	8	10.2	ne.	28	ne.	14	9	11	10	5.7	.0	.0
Columbia, S. C.	347	70	91	29.68	30.05	.00	78.2	+3.7	101	9	88	60	23	68	29	68	65	73	6.06	+2.6	8	7.5	ne.	21	ne.	18	13	10	7	4.6	.0	.0
Greenville, S. C.	1,040	70	78	28.97	30.04	.....	75.5	+4.9	101	9	86	57	23	65	30	65	61	69	.56	−3.1	5	5.8	ne.	19	e.	18	13	11	6	4.6	.0	.0
Augusta	182	62	77	29.58	30.03	−.02	78.8	+3.5	100	9	88	62	22	69	26	68	65	75	3.71	+.4	9	5.1	ne.	19	ne.	18	10	11	9	5.1	.0	.0
Savannah	65	73	152	29.96	30.01	−.02	80.4	+4.2	100	10	89	65	22	72	25	72	71	88	2.90	−2.5	10	9.3	ne.	31	sw.	30	11	10	9	5.1	.0	.0
Jackson ville	43	86	110	29.96	30.01	+.01	80.8	+2.5	96	10	89	69	21	73	22	73	72	83	5.89	−1.5	14	7.2	s.	22	ne.	14	8	13	9	5.6	.0	.0
Florida Peninsula							**81.9**	**+1.2**										**81**	**3.92**	**−3.2**										**5.7**		
Key West	21	10	64	29.96	29.97	+.03	83.1	+.9	92	21	89	72	23	77	17	77	75	79	3.18	−3.5	14	7.5	e.	26	sw.	22	6	20	4	5.2	.0	.0
Miami	25	124	168	29.96	29.99	+.02	81.7	+1.6	90	10	88	70	14	76	18	75	74	80	4.56	−3.8	17	6.6	se.	23	ne.	14	1	16	13	6.5	.0	.0
Tampa	35	88	197	29.98	29.99	+.02	80.9	+1.0	92	6	89	68	14	73	23	75	73	84	4.01	−2.4	13	8.4	e.	32	n.	14	5	20	5	5.4	.0	.0
East Gulf States							**78.4**	**+2.5**										**81**	**3.48**	**−0.7**										**5.0**		
Atlanta	976	5	72	29.03	30.03	−.02	76.2	+3.8	95	10	86	60	19	66	27	68	65	77	2.62	−.4	8	7.6	ne.	28	ne.	17	9	12	9	5.3	.0	.0
Macon	370	79	87	29.53	30.02	−.01	77.5	+2.7	96	10	87	60	22	68	24	70	67	82	1.87	−1.3	7	5.7	n.	22	n.	5	5	15	10	6.0	.0	.0
Thomasville	273	49	58	29.74	30.03	+.02	78.8	+2.0	96	11	88	62	22	70	27	72	70	..	2.64	−2.2	5	.....	.....	.....	.....	.....	9	14	7	5.3	.0	.0
Apalachicola	35	11	51	29.96	30.00	.....	79.8	+1.3	93	10	86	68	16	73	17	74	72	82	5.72	−2.4	9	7.9	ne.	26	se.	15	11	6	13	5.7	.0	.0
Pensacola	56	149	185	29.95	30.01	+.02	78.8	+.8	90	11	84	65	30	73	16	72	70	78	2.12	−3.2	9	10.8	ne.	44	sw.	26	15	8	7	4.5	.0	.0
Anniston	741	9	.....	.....	.....	.....	75.4	+4.1	92	4	86	55	22	65	28	.....	.....	.....	2.51	−1.2	6	.....	.....	.....	se.	.....	15	8	7	.....	.0	.0
Birmingham	700	11	48	29.38	30.04	+.01	77.0	+2.2	94	14	87	54	30	67	27	68	66	84	7.69	+4.3	11	5.5	e.	19	n.	4	14	8	8	4.5	.0	.0
Mobile	57	86	161	29.94	30.01	+.01	79.4	+1.3	95	13	88	60	30	71	21	72	70	82	4.81	−.2	9	8.5	ne.	28	nw.	30	12	9	9	4.8	.0	.0
Montgomery	218	92	105	29.77	30.02	.00	78.8	+2.5	94	11	88	60	30	70	25	70	68	83	3.08	+.1	9	6.1	ne.	26	w.	9	15	2	13	4.8	.0	.0
Meridian	375	67	92	29.69	30.02	.00	78.1	+3.6	96	9	88	51	30	68	28	70	68	87	2.14	−.8	9	5.2	e.	20	w.	20	14	9	7	4.3	.0	.0
Vicksburg	247	82	102	29.74	29.99	−.03	79.6	+3.3	97	13	89	52	30	70	25	71	68	75	4.12	+1.2	7	7.6	s.	35	s.	29	11	12	7	3.8	.0	.0
New Orleans	53	76	84	29.96	29.99	+.01	81.4	+2.2	94	11	88	60	30	74	22	74	72	82	2.48	−2.6	14	6.3	ne.	16	ne.	13	7	12	11	6.0	.0	.0
West Gulf States							**81.3**	**+4.2**										**69**	**1.49**	**−2.2**										**3.2**		
Shreveport	249	92	227	29.79	29.98	−.02	82.4	+5.5	103	4	94	54	30	71	30	70	66	70	.69	−2.1	5	9.5	s.	43	se.	5	20	7	3	3.2	.0	.0
Bentonville	1,303	12	51	28.62	29.95	−.07	78.2	+9.3	103	3	92	38	30	64	38	.....	.....	.....	.52	−3.2	1	5.9	s.	15	sw.	23	24	4	2	.....	.0	.0
Fort Smith	463	57	82	29.51	30.01	.00	83.4	+9.4	107	2	96	45	30	70	35	67	58	51	.23	−2.8	3	6.9	e.	26	nw.	29	25	4	1	2.1	.0	.0
Little Rock	357	94	102	29.71	29.99	−.04	80.8	+6.7	103	4	92	52	30	70	31	68	64	70	2.36	−.8	3	6.8	s.	23	s.	29	24	3	3	2.0	.0	.0
Austin	605	68	90	29.32	29.96	.....	81.2	+2.9	103	1	93	58	30	70	30	68	63	66	1.64	−1.8	7	7.0	s.	35	ne.	16	17	11	2	2.8	.0	.0
Brownsville	57	88	96	29.91	29.93	.....	80.2	−.4	94	2	88	65	25	73	24	73	72	85	3.62	−1.9	10	9.8	se.	28	ne.	30	13	9	8	4.7	.0	.0
Corpus Christi	20	11	78	29.91	29.96	+.01	81.0	+1.3	94	2	88	59	30	74	22	73	71	85	2.65	−1.8	11	10.8	s.	30	se.	11	17	9	4	3.7	.0	.0
Dallas	512	220	227	29.45	29.96	.....	83.0	.....	106	2	93	50	30	73	30	67	60	53	.18	−2.5	1	10.5	s.	33	n.	16	20	6	4	2.8	.0	.0
Fort Worth	670	92	110	29.24	29.96	−.03	83.7	+6.8	107	2	95	51	30	72	29	66	58	50	.12	−2.4	3	9.3	s.	29	n.	29	24	6	0	1.5	.0	.0
Galveston	54	106	114	29.96	29.97	−.01	80.8	+.7	90	26	86	64	30	76	21	73	71	78	3.28	−2.3	9	9.4	s.	29	nw.	30	17	8	5	3.8	.0	.0
Houston	138	157	190	29.91	29.98	.....	81.0	+2.0	98	1	91	59	30	71	26	71	68	80	2.30	−1.8	10	8.9	s.	29	w.	29	12	14	4	4.2	.0	.0
Palestine	510	64	72	.....	29.98	−.01	81.4	+4.4	103	1	93	53	30	70	.....	.....	.....	61	.15	−2.8	5	6.7	s.	22	se.	28	19	9	2	.....	.0	.0
Port Arthur	34	30	134	29.95	29.98	.....	81.2	.....	95	14	89	63	30	73	25	73	70	76	1.26	−3.6	5	11.2	s.	34	se.	19	9	17	4	4.5	.0	.0
San Antonio	693	111	301	29.36	29.96	.00	81.2	+2.2	102	2	92	59	30	70	28	70	65	69	1.90	−1.2	9	10.9	e.	32	se.	28	14	10	6	3.7	.0	.0
Ohio Valley and Tennessee							**73.8**	**+5.1**										**68**	**1.47**	**−1.5**										**3.4**		
Chattanooga	762	71	214	29.32	30.04	−.02	77.2	+5.0	98	14	89	56	30	66	31	66	64	78	1.80	−1.3	8	6.5	w.	30	n.	4	17	7	6	3.9	.0	.0
Knoxville	995	66	84	29.02	30.04	−.02	75.9	+5.3	99	9	88	54	23	64	31	64	61	73	.94	−1.7	5	4.6	w.	21	ne.	10	18	7	5	3.1	.0	.0
Memphis	399	78	86	29.70	29.99	−.04	80.1	+6.5	99	4	89	51	30	71	24	68	64	72	2.31	−.5	2	7.0	s.	27	nw.	29	19	7	4	3.0	.0	.0
Nashville	546	168	188	29.38	30.02	−.04	77.3	+5.5	99	14	89	50	30	65	40	64	58	61	.95	−2.5	3	7.0	s.	31	w.	29	19	7	4	3.3	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau Stations, September 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee—Continued	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F*		° *F*	° *F*		° *F*	° *F.*	° *F.*	° *F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Lexington	989	6					74.6	+6.1	101	8	89	46	22	60	45				1.59	−1.5	4		sw.				24	3	3		0.0	0.0
Louisville [1]	525	106	120	29.44	30.02	−0.04	75.6	+5.1	99	9	87	48	30	64	38	62	58	67	1.20	−1.6	5	7.7	sw.	26	sw.	4	22	5	3	2.3	.0	.0
Evansville	431	76	116	29.55	30.01	−.05	77.1	+6.4	101	8	89	46	30	65	35	64	57	57	.50	−2.8	3	7.4	sw.	28	sw.	29	21	6	3	2.8	.0	.0
Indianapolis [2]	823	98	129	29.16	30.01	−.05	72.4	+5.5	100	14	85	42	30	60	37	59	54	66	1.17	−2.2	3	7.4	sw.	30	n.	16	17	9	4	3.5	.0	.0
Terre Haute	575	63	149	29.39	30.00		74.3		103	15	88	43	30	61	39	61	54	59	1.17	−2.4	6	8.8	sw.	35	se.	16	22	6	2	2.6	.0	.0
Cincinnati [2]	627	11	51	29.49	30.02	−.05	73.5	+6.4	101	8	87	45	22	60	39	62	58	71	.71	−1.9	4	6.5	sw.	25	sw.	29	18	7	5	3.6	.0	.0
Columbus [2]	822	90	110	29.14	30.02	−.05	72.4	+5.9	98	7	84	47	22	60	34	59	54	65	1.39	−1.2	6	8.9	s.	33	sw.	29	13	11	6	3.9	.0	.0
Dayton	900	186	213	29.08	30.01		71.8	+5.2	98	14	84	45	30	60	34	59	55	60	1.23	−1.7	3	9.1	sw.	36	sw.	29	20	7	3	3.4	.0	.0
Elkins [2]	1,947	65	83	28.00	30.09	+.01	66.0	+3.0	91	8	80	39	23	52	44	57	55	86	2.41	−.7	10	4.8	w.	27	sw.	29	8	14	8	5.0	.0	.0
Parkersburg	637	77	84	29.35	30.03	−.05	71.6	+4.3	98	8	84	45	23	59	38	61	57	69	2.07	−.7	6	5.5	se.	25	nw.	4	18	9	3	3.2	.0	.0
Pittsburgh [1]	1,273	39	54	28.70	30.04	−.04	67.8	+1.4	95	8	80	44	18	56	33	58	53	70	2.58	.0	8	9.7	s.	34	w.	8	11	13	6	4.4	.0	.0
Lower Lake Region							65.3	+2.4										74	2.78	−0.2									5.3		
Buffalo [2]	768	243	280	29.27	30.03	−.03	62.8	+.4	89	3	70	42	26	55	25	56	53	78	3.12	+.2	14	12.6	s.	52	nw.	10	5	11	14	6.2	.0	.0
Canton	448	10	61	29.53	30.01		58.8	−.5	90	4	71	31	27	47	34	53	50	78	5.11	+1.8	12	6.8	sw.	30	sw.	25	8	15	7	5.3	1.8	.0
Ithaca	836	77	100	29.14	30.04		64.4	+2.8	98	15	76	35	18	53	39	56	52	74	2.86	−.2	15	8.1	nw.	31	nw.	10	5	16	9	6.0	.0	.0
Oswego	335	71	85	29.65	30.01	−.05	63.0	+1.8	94	16	72	40	27	54	29	56	52	73	2.07	−.6	15	8.6	s.	27	n.	26	6	10	14	6.8	.0	.0
Rochester [2]	523	86	102	29.43	30.03	−.03	64.6	+2.2	97	16	73	44	26	56	29	56	53	76	2.54	+.1	13	7.9	sw.	29	w.	10	8	9	13	6.1	.0	.0
Syracuse [2]	596	66	79	29.58	30.02	−.05	64.6	+2.8	97	16	75	40	18	54	35	56	53	77	1.58	−1.1	14	6.3	s.	28	sw.	10	6	11	13	6.3	.0	.0
Erie	714	57	81	29.26	30.02	−.04	65.8	+2.2	93	16	74	46	18	58	28	59	56	76	4.84	+1.4	12	7.1	se.	19	sw.	8	8	12	10	5.6	.0	.0
Cleveland [2]	762	267	318	29.16	30.02	−.04	67.4	+3.5	94	14	76	48	26	59	32	59	55	72	2.93	−.4	8	14.5	se.	49	s.	4	10	13	7	4.5	.0	.0
Sandusky	629	5	67	29.35	30.02	−.04	69.0	+3.7	98	7	79	47	22	59	35				3.45	+.5	9	8.2	sw.	27	nw.	16	14	8	8	4.7	.0	.0
Toledo [2]	628	79	87	29.35	30.03	−.03	68.0	+3.6	100	15	79	40	30	57	34	58	54	73	1.32	−1.5	6	8.8	n.	27	nw.	29	18	8	4	3.2	.0	.0
Fort Wayne	857	69	84	29.14	30.02		68.9	+3.5	99	7	82	40	30	56	38	57	52	67	.88	−2.2	7	8.2	nw.	25	w.	7	15	11	4	3.8	.0	.0
Detroit [1]	626	5	78	29.35	30.02	−.04	65.9	+2.4	100	15	77	39	30	54	35	57	54	73	2.70	−.4	10	9.1	n.	29	nw.	10	11	11	8	5.0	.0	.0
Upper Lake Region							61.5	+2.0										76	2.16	−1.2									4.8		
Alpena	609	13	89	29.36	30.03	.00	59.0	+1.4	97	14	68	35	24	50	33	54	51	80	2.78	−.2	12	11.0	nw.	30	nw.	10	9	11	10	5.1	.0	.0
Escanaba	612	41	49	29.36	30.02	+.01	57.0	−.1	84	14	66	29	30	48	28	53	50	79	2.94	−.4	12	11.1	s.	46	nw.	3	10	7	13	5.7	.0	.0
Grand Rapids [2]	707	70	244	29.26	30.00	−.05	66.0	+3.3	97	15	77	35	30	55	35	57	53	77	1.98	−1.6	8	10.1	s.	35	s.	3	15	9	6	4.0	.0	.0
Lansing	878	5	90	29.09	30.02		63.6	+2.2	94	15	75	35	30	52	35	56	53	77	1.41	−1.5	7	7.9	s.	22	w.	4	14	9	7	4.2	.0	.0
Marquette	734	44	69	29.20	30.00	.00	58.1	+.6	98	15	66	35	26	50	28	52	50	79	3.43	+.2	11	8.5	sw.	28	s.	28	7	11	12	6.1	.0	.0
Sault Sainte Marie [1]	724	5	33	29.22	30.02	.00	54.8	−.7	87	15	64	27	30	45	28	50	48	85	3.04	−1.2	14	7.4	se.	29	nw.	25	11	3	16	6.1	T	.0
Chicago	673	7	131	29.30	30.02	−.02	70.0	+4.8	100	7	79	44	30	61	33	60	54	66	.49	−2.6	4	10.6	sw.	27	sw.	7	16	9	5	3.4	.0	.0
Green Bay	617	109	141	29.33	30.00	−.02	62.6	+2.2	94	14	72	32	30	53	28	56	52	72	3.27	−.2	9	10.4	s.	31	sw.	3	13	6	11	5.0	.0	.0
Milwaukee [2]	681	97	221	29.27	30.02	−.01	67.5	+5.0	99	15	77	39	30	58	33	57	53	70	1.53	−1.8	9	12.4	n.	36	sw.	28	16	7	7	3.9	.0	.0
Duluth	1,133	5	47	28.75	29.97	−.01	56.6	+1.5	89	15	65	29	26	48	32	50	47	80	.72	2.6	7	11.0	ne.	39	nw.	25	14	6	10	4.7	.0	.0
North Dakota							59.0	+2.0										60	0.93	−0.7									4.6		
Moorhead, Minn	940	50	58	28.96	29.93	−.03	61.0	+2.8	95	14	74	24	26	48	39	51	44	63	.59	−1.6	7	8.8	s.	26	nw.	24	12	8	10	5.0	.0	.0
Bismarck [2]	1,674	8	57	28.19	29.95	+.01	60.2	+2.1	93	18	74	26	25	48	47	49	40	57	.24	−1.0	5	7.8	nw.	28	nw.	24	12	8	10	4.7	T	.0
Devils Lake	1,478	11	44	28.37	29.94	.00	57.4	+1.5	93	18	71	20	25	44	40	48	41	63	.50	−1.1	10	9.2	s.	25	n.	24	10	10	10	5.0	.3	.0
Lemmon, S. Dak	2,602	4	38																												
Grand Forks	832	11	71				57.2	+.8	96	2	71	24	25	44	43	51	47		2.32	+.3	10	9.1	n.								.2	.0
Williston	1,878	42	50	27.96	29.92	−.01	59.4	+2.8	94	11	73	23	29	46	42	49	40	58	.99	−.1	8	7.5	sw.	26	n.	24	18	7	5	3.6	.1	.0
Upper Mississippi Valley							70.4	+5.1										64	0.97	−2.7									3.2		
Minneapolis, St. Paul, Minn. [1]	838	32	61	29.07	29.96	−.03	64.2	+2.8	98	15	75	26	30	53	37	55	49	67	2.31	−.8	7	10.4	s.	42	nw.	3	13	6	11	4.8	.0	.0
Springfield, Minn	1,025	4	42				64.8		100	14	78	23	30	51	42	54	47		.58		3	6.6	s.								.0	.0
La Crosse [2]	714	11	48	29.27	29.99	−.02	65.4	+3.2	97	7	77	35	30	54	37	56	52	72	.93	−3.1	6	5.0	s.	16	n.	28	15	6	9	4.1	.0	.0
Madison	974	70	78	28.97	29.99	−.04	66.8	+4.4	97	7	77	40	30	56	33	57	51	65	1.57	−2.2	6	8.1	s.	21	s.	3	13	7	10	4.7	.0	.0
Charles City	1,015	10	51	28 92	30.00	.00	65.8	+4.8	100	6	79	29	30	53	42	55	50	65	.83	−2.8	5	6.4	se.	21	sw.	15	17	10	3	3.0	T	.0
Davenport	606	66	161	29.36	30.01	−.02	70.8	+5.2	99	14	82	37	30	60	33	59	53	62	.70	−2.8	4	9.6	sw.	26	s.	3	21	4	5	3.1	.0	.0
Des Moines [2]	860	5	99	28.95	29.97	−.05	70.5	+4.9	102	7	84	35	30	57	41	57	50	56	1.20	−2.5	5	9.9	n.	31	nw.	3	21	5	4	2.2	.0	.0
Dubuque	699	60	79	29.25	30.00	−.03	68.4	+4.4	99	7	80	36	30	57	35	58	53	65	.69	−3.3	5	6.0	s.	17	ne.	20	15	9	6	3.7	.0	.0
Keokuk	614	64	78	29.34	29.99	−.04	73.1	+5.6	100	15	84	37	30	62	36	60	54	60	.23	−3.6	1	7.2	sw.	22	s.	3	20	5	5	2.8	.0	.0
Cairo	358	87	93	29.63	30.00	−.05	77.4	+5.9	99	8	88	49	30	66	30	65	60	62	1.20	−1.7	2	6.8	s.	20	n.	30	21	8	1	2.1	.0	.0
Peoria [2]	609	11	45	29.30	30.00	−.04	71.7	+7.4	102	14	85	38	30	58	39	59	54	67	.85	−3.2	4	5.0	s.	16	s.	3	21	7	2	2.5	.0	.0
Springfield, Ill. [2]	636	5	191	29.35	30.00	−.05	74.3	+6.7	100	14	87	44	30	62	38	60	55	67	.14	−3.5	1	10.9	s.	27	s.	3	19	6	5	3.0	.0	.0
St. Louis [2]	568	179	303	29.40	30.00	−.04	76.9	+6.4	100	8	88	48	30	66	30	63	56	54	1.01	−2.4	4	10.6	sw.	30	s.	3	22	7	1	1.8	.0	.0
Missouri Valley							72.9	+6.6										54	0.48	−2.7									2.9		
Columbia, Mo. [2]	784	6	66	29.17	29.99	−.04	75.4	+7.2	103	3	88	38	30	63	41	61	53	60	.58	−3.8	3	7.3	s.	21	sw.	3	19	9	2	3.2	.0	.0
Kansas City [1]	750	32	45	29.18	29.97	−.05	76.7	+7.8	107	3	89	38	30	64	38	61	53	52	.54	−4.0	3	8.5	sw.	34	sw.	3	20	5	5	2.8	.0	.0
St. Joseph [2]	967	11	49	29.11	29.97		75.6	+7.2	106	3	88	36	30	63	36	60	53	58	.42	−3.5	1	8.7	s.	27	sw.	3	20	7	3	2.7	.0	.0
Springfield, Mo. [2]	1,324	5	78	28.60	30.00	−.03	77.6	+8.7	102	3	90	39	30	65	37	62	57	63	.70	−2.8	1	7.7	se.	24	w.	3	22	7	1	2.4	.0	.0
Topeka	987	65	87	28.93	29.96		77.0	+8.3	108	2	91	37	30	63	41	60	49	45	.40	−3.4	2	9.5	s.	32	sw.	6	19	10	1	2.7	.0	.0
Lincoln [2]	1,189	11	81	28.71	29.95	−.04	73.0	+6.6	105	6	88	31	30	58	52	56	44	45	.26	−2.7	2	10.8	s.	31	nw.	3	22	4	4	2.6	.0	.0
Omaha [1]	982	31	44	28.93	29.97	−.03	71.8	+5.0	104	6	86	32	30	57	51	57	49	53	.41	−2.8	5	10.7	se.	34	w.	3	21	4	5	2.4	.0	.0
Valentine	2,598	47	54	27.28	29.96	.00	66.0	+3.5	100	13	81	31	25	51	46	53	44	54	.67	−.6	7	8.9	s.	27	n.	22	17	8	5	3.4	.5	.0
Sioux City	1,138	64	106	28.76	29.95	−.03	70.2	+6.8	103	6	84	33	29	56	45	57	48	51	.31	−2.7	5	10.0	s.	36	se.	5	17	8	5	3.3	T	.0
Huron [1]	1,289	27	41	28.58	29.94	−.02	65 8	+4.5	102	13	81	23	29	50	45	53	43	54	.51	−1.1	4	12.9	s.	49	s.	2	15	8	7	3.6	T	.0
Northern Slope							60.1	+3.2										52	0.68	−0.5									4.2		
Billings	3,140	5		26.33	29.97		60.4		93	1	74	30	26	46	44	48	36	47	.22		4	10.1	sw.	39	n.	6	12	11	7	4.4	.5	.0
Havre	2,507	11	67	27.34	29.96	+.02	59.2	+2.8	90	4	74	33	29	45	47	48	38	53	.90	−.4	8	7.8	w.	26	w.	15	15	9	6	4.1	T	.0
Helena	4,124	85	111	25.83	29.98	+.01	57.4	+.8	85	4	71	31	28	44	39	47	36	50	.89	−.4	8	8.0	sw.	24	w.	15	15	6	9	4.6	.7	.0
Missoula	3,263	80	91				59.6	+4.2	90	4	75	33	29	44	45	48	39	58	.88	−.6	6	6.7	se.	32	e.	24	13	10	7	4.3	.0	.0
Kalispell	2,973	48	56	26.95	29.98	+.02	56.2	+2.7	85	4	69	32	29	43	43	47	39	57	.96	−.3	7	6.7	nw.	22	w.	1	11	8	11	5.4	.0	.0
Miles City [2]	2,371	48	55	27.23	29.95	.00	62.2	+1.0	95	1	76	30	29	48	44	49	39	52	.62	−.4	7	5.7	s.	22	n.	9	13	9	8	4.4	T	.0
Rapid City [2]	3,259	50	58	26.68	29.95	−.01	65.3	+4.9	94	1	79	30	26	51	41	50	37	45	.80	−.4	5	7.8	w.	32	nw.	7	14	11	5	4.0	T	.0
Cheyenne [1]	6,144	5	39	24.05	29.98	+.02	60.2	+3.2	87	2	76	29	30	45	43	46	36	50	.49	−7	7	10.9	nw.	34	w.	22	13	8	9	4.6	T	.0
Lander	5,352	60	68	24.71	29.96	.00	58.6	+2.9	85	1	74	29	30	43	44	47	37	52	.64	−.3	7	5.4	sw.	25	sw.	6	15	7	8	4.0	.0	.0
Sheridan	3,790	10	47	26.12	29.99		58.1		91	11	76	29	30	40	52	47	40	62	.75	−.5	6	4.5	s.	18	nw.	6	14	13	3	4.2	T	.0
Yellowstone Park	6,235	12	46	23.97	30.07	+.10	53.2	+3.1	80	21	67	25	29	39	44	42	33	52	.36	−.8	8	8.4	sw.	30	sw.	6	12	17	1	3.9	.0	.0
North Platte [2]	2,821	11	51	27.11	29.95	−.02	68.8	+6.7	100	5	84	35	26	53	49	53	43	51	.20	−1.2	3	7.6	s.	25	nw.	3	20	7	3	3.0	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau Stations, September 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Middle Slope							73.4	+5.4										44	0.31	−1.8										2.8		
Denver [2]	5,292	106	113	24.77	29.94	−0.02	67.0	+4.1	93	2	80	39	29	54	37	51	39	45	0.48	−0.5	4	7.3	s.	23	n.	28	13	8	9	4.5	0.0	0.0
Pueblo [2]	4,690	79	86	25.23	29.93	−.03	69.0	+4.4	96	2	83	38	30	55	41	53	43	47	.32	−.4	5	6.2	e.	28	ne.	28	13	13	4	4.1	.0	.0
Concordia	1,392	50	58	28.52	29.96	−.03	73.7	+5.4	107	2	88	35	30	60	48	58	46	44	.60	−2.0	3	8.8	sw.	24	nw.	3	23	3	4	2.4	.0	.0
Dodge City	2,509	10	86	27.41	29.95	−.03	73.2	+3.8	104	1	87	39	26	60	40	56	44	41	.10	−1.8	3	12.9	sw.	39	ne.	28	22	7	1	2.3	.0	.0
Wichita [2]	1,358	85	93	28.51	29.95	−.05	77.6	+7.0	106	3	90	38	30	65	32	60	50	45	.30	−2.8	5	10.6	s.	29	sw.	3	25	4	1	1.9	.0	.0
Oklahoma City [2]	1,214	10	47	28.61	29.96	−.04	80.2	+7.4	105	1	94	40	30	67	41	62	51	44	.06	−3.0	1	8.2	s.	23	n.	29	27	1	2	1.7	.0	.0
Chadron, Nebr.	3,439	4	58																												
Southern Slope							77.7	+4.2										50	0.55	−2.0										2.2		
Abilene [2]	1,738	10	56	28.17	29.94	−.02	80.6	+5.3	103	3	94	49	30	68	41	62	51	47	.03	−2.7	2	9.3	s.	25	s.	28	23	6	1	1.8	.0	.0
Amarillo [2]	3,676	10	49	26.38	29.95	−.01	75.8	+6.5	102	3	90	46	30	62	37	57	47	48	.45	−1.8	3	8.4	s.	21	nw.	29	26	4	0	1.8	.0	.0
Del Rio	960	63	71	28.94	29.90	−.04	81.2	+2.0	100	2	92	62	30	71	27	67	60	58	1.07	−1.9	5	9.0	se.	34	n.	27	16	11	3	3.4	.0	.0
Roswell	3,566	78	82	26.41	29.94	+.02	73.2	+2.9	99	3	87	50	24	60	40	58	47	47	.65	−1.5	2	7.4	s.	22	se.	19	23	4	3	1.8	.0	.0
Southern Plateau							74.5	+1.6										52	2.63	+1.8										3.4		
El Paso [2]	3,778	82	101	26.06	29.88	.00	77.2	+3.3	98	2	89	55	24	66	34	58	46	42	.90	−.4	4	8.2	e.	22	ne.	16	24	4	2	1.8	.0	.0
Albuquerque [1]	5,314	5	34	24.82	29.92	.....	70.6	+2.7	94	1	83	48	30	58	32	56	46	50	1.19	+.4	6	7.9	ne.	40	nw.	25	18	8	4	3.4	.0	.0
Santa Fe	7,013	38	53	23.37	29.98	+.05	63.5	+2.6	85	1	74	42	30	53	27	51	42	56	2.53	+1.1	9	5.4	e.	20	w.	25	10	12	8	5.1	.0	.0
Flagstaff	6,907	10	59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phoenix [2]	1,107	39	51	28.71	29.84	+.03	82.4	−.3	110	1	94	59	29	71	34	68	61	58	5.41	+4.7	9	5.2	e.	26	sw.	11	18	4	8	3.7	.0	.0
Yuma	141	9	54	29.68	29.82	+.04	83.2	−.5	112	1	95	60	27	71	38	69	62	55	5.13	+4.8	6	5.3	n.	20	se.	24	18	6	6	3.2	.0	.0
Independence	3,957	5	26	25.96	29.94	+.08	69.9	+1.9	93	1	77	45	14	63	39	.....	.....	.....	.62	+.5	4	4.4	.....	17	n.	23	.....	.....	.....	.....	.....	.....
Middle Plateau							64.0	+1.9										52	1.46	+0.8										4.1		
Reno [2]	4,527	61	76	25.60	29.96	+.01	63.0	+2.5	89	9	78	35	14	48	43	48	38	55	.84	+.6	7	5.6	w.	27	s.	11	17	10	3	3.3	.0	.0
Tonopah	6,090	12	20	.....	.....	.....	63.8	.....	86	1	75	34	14	53	32	50	38	.....	.61	.....	8	.....	se.	.....	.....	.....	.....	.....	.....	.....	.0	.0
Winnemucca	4,344	18	56	25.63	29.97	+.04	62.0	+2.8	97	19	82	27	15	42	55	46	32	39	.25	−.2	5	6.8	ne.	31	sw.	11	16	8	6	3.4	T	.0
Modena	5,473	10	46	24.68	29.94	+.02	60.8	+.8	86	1	73	38	15	48	39	51	44	61	3.24	+2.5	11	8.6	sw.	31	sw.	2	14	4	12	5.3	.0	.0
Salt Lake City [1]	4,227	32	46	25.76	29.95	.00	66.3	+1.9	93	1	78	40	15	54	37	52	43	51	.58	−.4	6	7.2	s.	27	s.	11	15	6	9	4.1	.0	.0
Grand Junction	4,602	60	68	25.43	29.97	+.02	67.9	+1.7	93	1	80	48	15	56	34	55	46	52	2.37	+1.4	10	5.4	se.	24	w.	4	14	6	10	4.4	.0	.0
Northern Plateau							63.2	+2.8										49	0.53	−0.2										3.4		
Baker	3,471	36	54	26.57	30.02	+.03	58.8	+2.8	90	20	75	33	29	42	48	45	34	55	.56	−.2	4	6.1	s.	29	w.	4	17	6	7	3.6	.0	.0
Boise [2]	2,739	79	87	27.19	29.96	−.01	64.3	+2.4	92	20	78	41	29	50	37	51	41	55	1.53	+1.0	3	4.8	nw.	15	w.	13	19	6	5	2.9	.0	.0
Pocatello [1]	4,478	5	31	25.51	29.98	+.02	60.6	+.4	87	21	76	32	30	45	48	48	36	47	.43	−.4	7	9.7	sw.	31	sw.	27	15	11	4	3.6	.0	.0
Spokane [2]	1,929	101	110	27.91	29.97	−.01	62.1	+2.9	90	20	76	38	29	48	41	50	39	51	.23	−.7	3	6.2	s.	22	sw.	5	17	6	7	3.8	.0	.0
Walla Walla	991	57	65	28.91	29.98	−.02	67.1	+3.3	91	10	80	46	29	54	35	53	40	40	.38	−.6	4	5.5	s.	19	sw.	5	19	3	8	3.5	.0	.0
Yakima	1,076	58	67	28.85	29.99	.....	66.2	+5.1	94	21	80	41	30	52	41	53	42	47	.05	−.5	1	5.8	nw.	20	nw.	5	17	10	3	3.1	.0	.0
North Pacific Coast Region							61.2	+2.3										72	0.92	−1.3										4.4		
North Head	211	8	56	29.83	30.05	+.02	57.4	+.9	77	19	62	49	13	52	26	54	53	90	.68	−2.3	14	11.3	n.	34	s.	14	10	7	13	5.7	.0	.0
Seattle [2]	125	90	321	30.01	30.05	+.04	61.1	+3.0	80	21	70	47	30	53	26	54	50	76	1.30	−.5	8	7.2	n.	24	sw.	14	13	7	10	4.7	.0	.0
Tacoma	263	172	201	29.84	30.04	+.02	59.0	+1.7	78	21	67	44	30	51	24	.....	.....	.....	.62	−1.5	7	7.4	n.	26	sw.	10	15	7	8	4.0	.0	.0
Tatoosh Island	86	9	55	29.96	30.05	+.04	54.4	+1.4	65	20	58	47	12	51	14	52	51	89	2.41	−2.3	9	10.8	sw.	57	ne.	20	10	6	14	6.1	.0	.0
Medford [1]	1,329	29	58	28.58	29.97	.....	65.8	+2.5	98	21	84	37	15	48	52	53	42	52	.26	−.3	4	.....	nw.	.....	.....	.....	19	7	4	2.9	.0	.0
Portland, Oreg. [2]	154	68	106	29.98	30.02	−.01	65.4	+3.7	88	21	75	47	13	56	30	57	52	68	.60	−1.4	4	5.7	nw.	15	nw.	10	15	6	9	4.2	.0	.0
Roseburg	510	45	76	29.45	29.99	−.03	65.6	+2.7	98	21	80	42	7	51	45	56	48	60	.55	−.7	4	3.5	n.	18	n.	6	18	8	4	3.0	.0	.0
Middle Pacific Coast Region							68.0	+3.1										61	0.60	−0.1										3.7		
Eureka	60	72	88	29.93	30.00	−.01	57.6	+1.7	85	21	63	45	18	52	25	54	52	85	.05	−1.0	3	5.4	n.	24	n.	6	14	8	8	4.8	.0	.0
Redding [1]	722	20	34	29.13	29.90	.....	75.2	+1.7	102	19	87	50	14	63	37	57	41	38	.92	+.1	5	7.7	nw.	23	nw.	11	17	6	7	3.8	.0	.0
Sacramento [2]	66	92	115	29.86	29.88	−.01	73.1	+3.8	102	23	87	46	14	59	42	58	47	48	.35	.0	3	6.7	s.	21	s.	11	19	7	4	2.8	.0	.0
San Francisco	155	112	132	29.78	29.94	.00	66.2	+5.3	97	21	74	53	13	58	32	58	54	73	1.06	+.6	4	8.4	w.	26	w.	19	17	9	4	3.4	.0	.0
South Pacific Coast Region							75.1	+5.3										58	4.12	+4.0										4.3		
Fresno [1]	327	97	105	29.58	29.87	.00	75.9	+2.5	104	20	91	50	14	61	44	60	48	45	.17	.....	4	6.0	nw.	22	se.	20	16	8	6	3.6	.0	.0
Los Angeles	338	159	191	29.52	29.88	.00	76.6	+7.6	107	20	86	57	14	67	31	63	55	56	5.67	+5.5	5	6.0	sw.	29	se.	24	14	12	4	3.9	.0	.0
San Diego [1]	87	62	70	29.85	29.87	−.02	72.8	+5.7	106	21	80	57	14	66	29	65	61	72	2.58	+2.5	9	6.6	nw.	34	s.	25	11	9	10	5.5	.0	.0
West Indies																															
San Juan, P. R.	82	9	84	29.89	29.97	.....	80.7	+.2	89	22	86	72	4	76	15	.....	.....	.....	6.23	+.3	15	8.9	e.	29	ne.	4	6	18	6	5.3	.0	.0
Panama Canal																															
Balboa Heights	118	6	92	.....	[3]29.84	+.02	79.8	.0	91	1	86	71	13	74	17	.....	.....	[3]86	8.12	.0	23	4.4	nw.	22	n.	16	1	6	23	7.9	.0	.0
Cristobal	36	6	97	.....	[3]29.85	+.02	80.5	+.1	89	27	86	73	11	76	15	76	75	[3]86	16.91	+4.4	24	5.8	s.	19	w.	10	1	3	26	8.8	.0	.0
Alaska																															
Fairbanks	454	11	87	[4]29.32	[4]29.84	.....	42.0	−1.4	60	25	51	12	19	33	35	39	35	74	1.16	−.2	14	6.1	e.	22	nw.	17	3	9	18	7.8	T	.0
Juneau	80	96	116	[4]29.84	[4]29.93	.....	49.6	−.6	62	10	53	39	12	46	18	47	44	83	14.09	+3.9	25	7.4	s.	33	ne.	15	2	0	28	9.4	.0	.0
Nome	22	5	57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hawaiian Islands																															
Honolulu	38	86	100	29.92	29.98	.....	77.0	−1.2	85	6	82	69	19	72	14	70	66	72	3.78	+2.5	12	8.6	e.	23	e.	10	5	23	2	4.9	.0	.0

[1] Data are airport records.
[2] Barometric and hygrometric data from airport, other data city office records.
[3] Observations taken hourly.
[4] Pressure not reduced to a mean of 24 hours.

NOTE.—Except as indicated by notes 1 and 2, data in table 2 are city office records.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, September 1939*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+ mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99				52.4	−0.4	58.9	45.8	68	33	3.18	−0.41	0.0
Sydney, Cape Breton Island	48	29.82	29.95	−.09	57.2	+.2	66.7	47.7	84	35	2.78	−.59	.0
Halifax, Nova Scotia	88	29.73	29.99	−.06	59.6	+1.3	67.2	52.1	86	39	4.75	+1.01	.0
Yarmouth, Nova Scotia	65	29.90	30.00	−.60	57.3	+1.3	64.9	49.7	77	36	3.53	+.02	.0
Charlottetown, Prince Edward Island	38	29.88	29.96	−.06	58.2	+1.3	66.7	49.8	82	33	4.04	+.35	.0
Chatham, New Brunswick	28	29.82	29.92	−.05	54.6	−1.8	65.2	44.1	91	24	4.65	+1.62	.0
Father Point, Quebec	20	29.92	29.94	−.04	49.6	−.1	56.2	43.1	77	28	4.08	+1.10	.0
Quebec, Quebec	296												
Doucet, Quebec	1,236												
Montreal, Quebec	187												
Ottawa, Ontario	236	29.64	30.00	−.03	56.8	−1.2	66.7	46.8	94	31	2.59	−.21	.0
Kingston, Ontario	285	29.72	30.03	−.02	58.4	−1.6	69.1	47.8	87	28	3.54	+.74	.0
Toronto, Ontario	379	29.62	30.03	−.02	61.8	+1.4	69.8	53.6	92	41	2.52	−.44	.0
Cochrane, Ontario	930				50.1	−1.3	59.5	40.7	89	19	2.38	−.69	T
White River, Ontario	1,244	28.67	30.02	+.03	50.0	.0	60.6	39.3	88	15	3.40	+.37	.7
London, Ontario	808	29.17	30.05	−.01	61.6	+1.1	72.5	50.8	94	35	2.80	−.08	.0
Southampton, Ontario	656	29.32	30.03	−.01	58.7	−.5	68.2	49.2	91	33	1.96	−.92	.0
Parry Sound, Ontario	688	29.34	30.03	.00	58.2	+.8	66.9	49.6	87	36	2.97	−.64	.0
Port Arthur, Ontario	644	29.28	29.99	+.01	51.6	−1.6	60.6	42.6	77	20	3.66	+.28	.0
Winnipeg, Manitoba	760	29.07	29.93	−.04	55.3	+1.1	66.0	44.6	87	23	1.62	−.64	T
Minnedosa, Manitoba	1,690	28.14	29.95	+.01	52.9	+.9	65.5	40.3	87	21	1.47	−.13	2.0
Le Pas, Manitoba	860	28.94	29.91	+.01	48.5	−.7	60.3	36.7	80	20	1.05	−.76	.0
Qu'Appelle, Saskatchewan	2,115	27.68	29.94	−.02	54.2	+2.3	68.3	40.0	89	21	.51	−1.12	T
Moose Jaw, Saskatchewan	1,759				57.0	+3.5	69.6	44.4	89	26	.31	−.96	T
Swift Current, Saskatchewan	2,392	27.17	29.98	+.03	54.0	+.7	66.2	41.9	66	42	.33	−.94	.8
Medicine Hat, Alberta	2,365	27.47	29.95	+.02	56.3	+.3	69.6	43.0	89	27	1.23	+.07	.0
Calgary, Alberta	3,540	26.32	29.99	+.03	51.8	+1.3	63.1	40.4	81	31	1.50	−.03	.1
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.38	29.93	−.01	51.8	+1.6	62.0	41.5	82	27	.91	−.64	.2
Battleford, Saskatchewan	1,592	28.20	29.92	−.02	52.6	+1.1	65.4	39.7	85	12	.25	−1.08	T
Edmonton, Alberta	2,150	27.57	29.93	+.02	49.4	−.8	61.5	37.2	80	19	1.81	+.50	.6
Kamloops, British Columbia	1,262	28.64	29.98	.00	60.3	+1.7	72.1	48.5	83	37	.83	+.01	.0
Victoria, British Columbia	230	29.79	30.03	+.04	58.0	+2.0	65.7	50.4	75	47	.31	−1.34	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20	30.04	30.07	+.08	54.8	+1.2	60.4	49.2	68	44	3.14	−1.75	.0
Prince Rupert, British Columbia	170	29.86	30.04	+.07	52.8	−.8	58.6	46.9	70	40	9.86	+2.07	.0
St. George's, Bermuda	158		30.04	−.03	78.9	+1.0	83.9	73.9	90	69	5.19	−.05	.0

LATE REPORTS FOR AUGUST 1939

Father Point, Quebec	20	29.93	29.95	+0.03	58.8	+3.1	66.6	50.9	77	45	3.06	−0.05	0.0
Quebec, Quebec	296	29.64	29.96	+.01	69.3	+5.7	77.7	60.9	85	49	4.84	+1.01	.0
Kamloops, British Columbia	1,262	28.64	29.96	+.04	70.5	+2.2	86.5	54.5	100	44	T	−1.08	.0
Estevan Point, British Columbia	20	30.03	30.06	+.02	57.5	+.7	63.6	51.4	75	48	3.52	+.24	.0
Prince Rupert, British Columbia	170	29.90	30.08	+.05	56.0	−1.6	62.7	49.4	73	43	6.81	+1.61	.0
St. George's, Bermuda	158		30.05	−.05	80.5	+1.0	85.8	75.1	89	79	4.36	−1.56	.0

TABLE 4.—*Severe local storms, September 1939*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials]

[The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United State Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Hand County, S. Dak.	1–2	P. m.	[1] 2½		$3,000	Electrical	A prairie fire caused by lightning destroyed hay.
Johnston, S. C., vicinity of	2	3 p. m.			500	do	Loss of barn, feed, and mule.
Wright, Hennepin, and Anoka Counties, Minn.	3	10:30–11:30 a. m.	[1] 3		25,600	Thundersqualls and hail.	Several barns, outbuildings, silos, and windmills demolished; residences and barns unroofed or otherwise damaged; many trees uprooted or branches broken off; much corn lodged; haystacks scattered.
Marquette, Mich., vicinity of	3	10:33 – 10:55 a. m.	[1] 3		10,000	Hail	Windows broken; roofs damaged; loss to gardens.
Marinette County, Wis.	3	8:25 p. m.			2,000	Wind	Many trees blown over; poles and wires down; streets blocked with debris.
Bedford, Va.	3	P. m.			2,000	Thunderstorm	Barn and contents burned.
Door County, Wis.	3				25,000	Wind	Much damage to cherry orchards; many poles down.
Lincoln County, Tenn.	4					do	Several houses unroofed.
Sparta, Tenn., and vicinity	4	5:30 p. m.		1	5,000	Tornado	Property damaged.
Park County, Utah	4					Electrical	A flock of 835 sheep killed by lightning as they slept, only 15 escaped; loss of several thousand dollars.
Brookville, Ohio, vicinity of	9					Wind and hail	Damage to power lines and buildings; loss to crops.
New York State, western and west-central portions.	10	P. m.		4	100,000	do	Trees down; highways and streets blocked; damage to telephone and power lines. Many small buildings demolished; dwellings damaged. In Hannibal, N. Y., hail caused much loss to fruits and other crops over a path 1 to 4 miles wide and from 8 to 10 miles long. In Baldwinsville, N. Y., much loss in tobacco from hail.
Minneapolis and St. Paul, Minn., and vicinity.	11				25,000	Heavy rain	Sewers overflowed; basements flooded; pavements damaged; highways inundated.
De Kalb, Cherokee, and Etowah Counties, Ala.	14	3:30–6 p. m.			2,100	Wind	Property damaged.
Blunt, S. Dak., vicinity of	14	10:10 p. m.	[1] 6		7,500	do	Property damaged; telephone poles down.
Calhoun, Ga., vicinity of	14		[1] 4			Wind and hail	Much crop loss; considerable damage to roofs; windows broken. No estimate of damage available.
Hamilton County, Ind.	16	3:30 p. m.		0	500	Tornado	Property damaged.
Jay and Randolph Counties, Ind.	16	6:45 p. m.		0	500	do	Storm occurred along the Jay-Randolph county line. Property damaged.
Springfield, Ill.	16				2,000	Wind	Property damaged.
Boone County, Ind.	16				950	Wind and hail	Property damage, $200; loss to crops, $750.
San Diego, Calif.	19	10:30 p. m.	6		1,000	Straight-line wind	Property damaged.
Priest Valley, Calif.	21	P. m.	880			do	Large trees uprooted; several sheds unroofed.
California, southern coastal region	24–25		[1] 100	45	2,000,000	Tropical	Damage to small craft, to buildings, and power and communication lines along the coast, $1,500,000; loss to crops, $500,000. The torrential rain that resulted from this storm also did great damage to dates, truck, and cut hay in the irrigated desert region of Riverside and Imperial Counties, but estimate of these losses are not available. A more detailed report of this storm will appear in a later issue of this Review.
Cattaraugus County, N. Y.	29	6 p. m.		1	100,000	Tornadic winds	Barns and sheds demolished; dwellings damaged; cattle killed; loss to crops and grains in storage; 5 persons injured.
Mount Vernon, Ohio, vicinity of.	29					Wind	Buildings unroofed; loss to crops.
Toledo, Ohio	30					Thunderstorm	Considerable damage to shade trees.

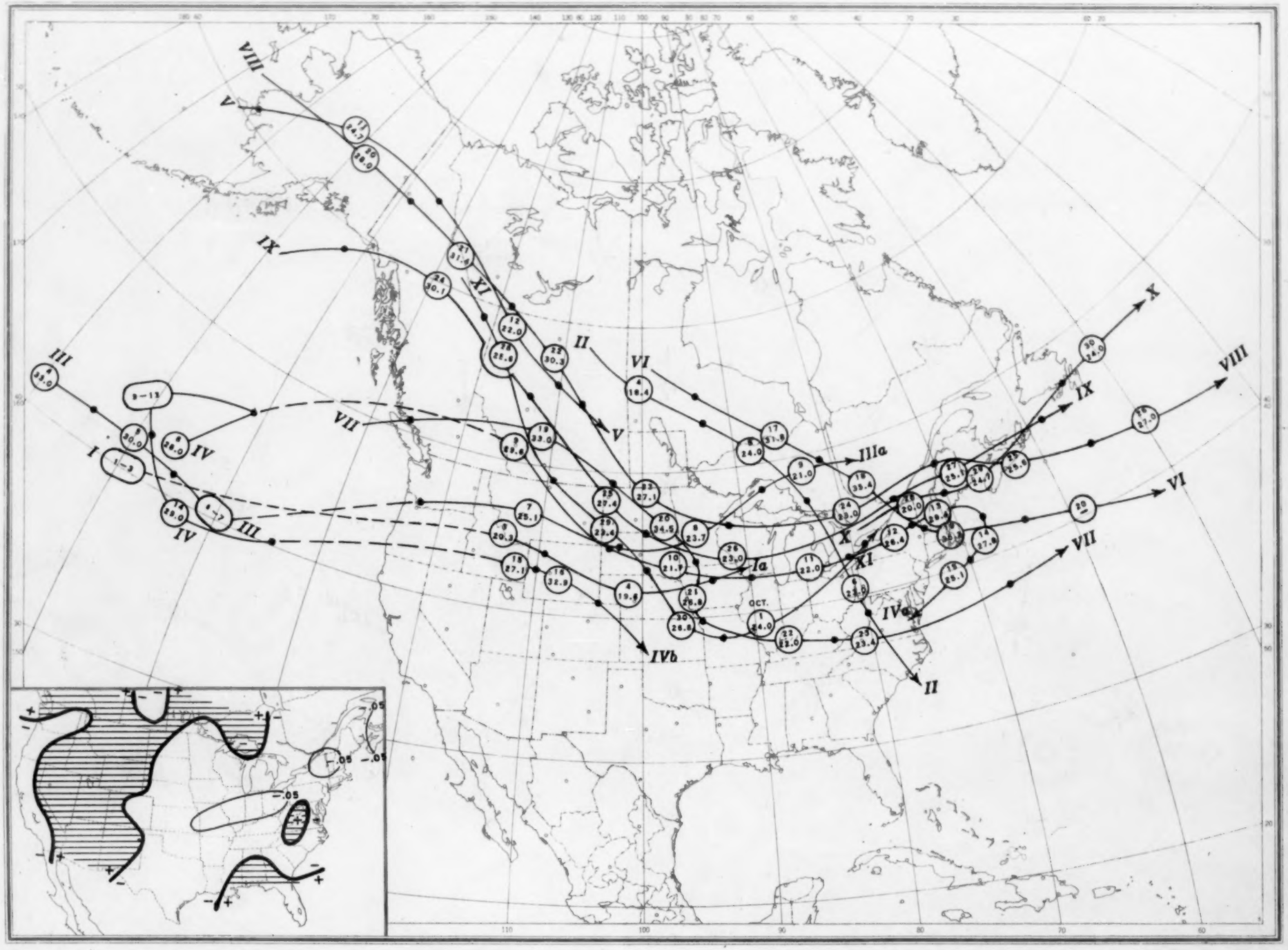
[1] Miles instead of yards.

○

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, September 1939

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, September 1939

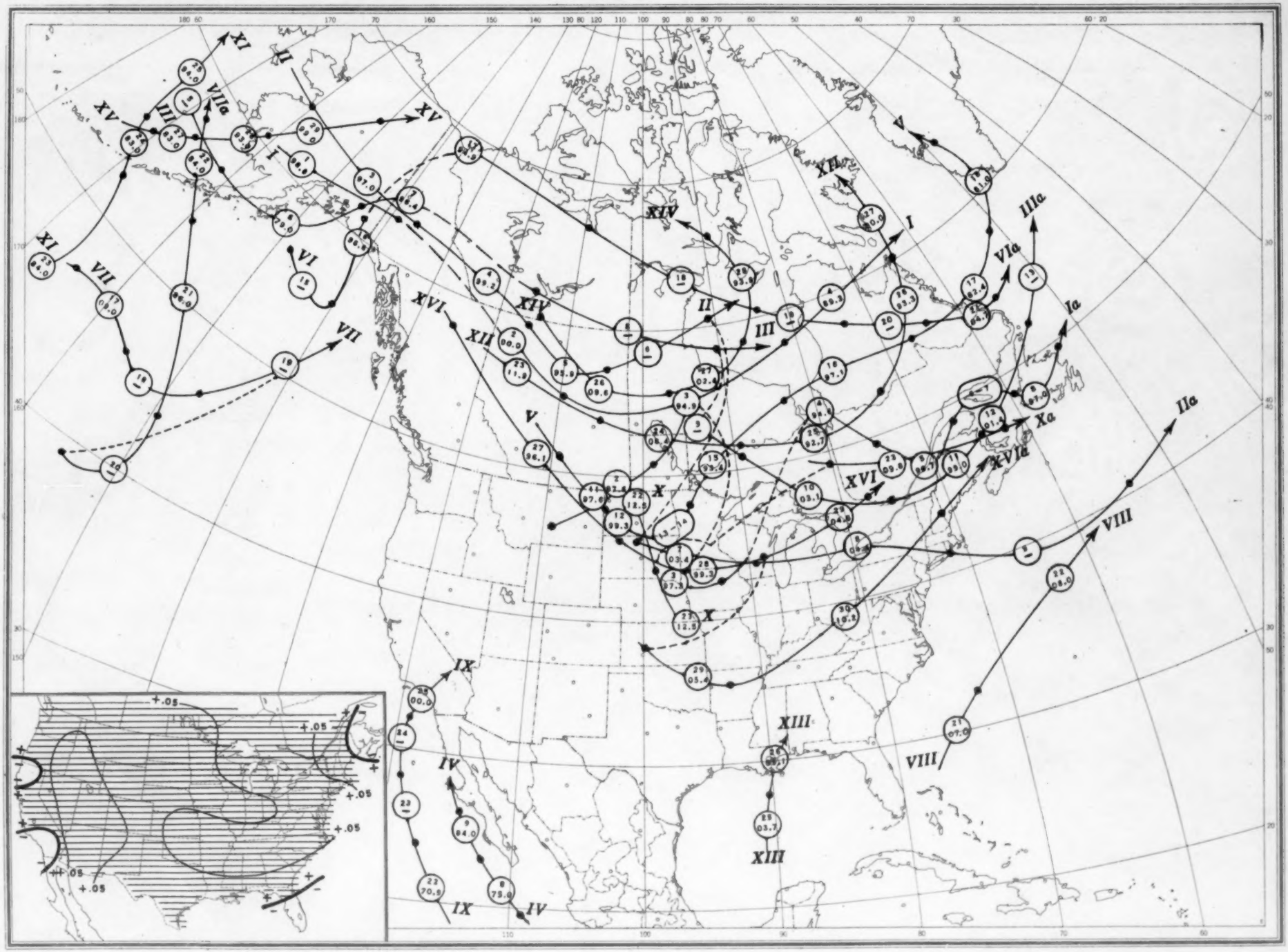
Chart II. Tracks of Centers of Anticyclones, September 1939. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, September 1939. (Inset) Change in Mean Pressure from Preceding Month



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, September 1939

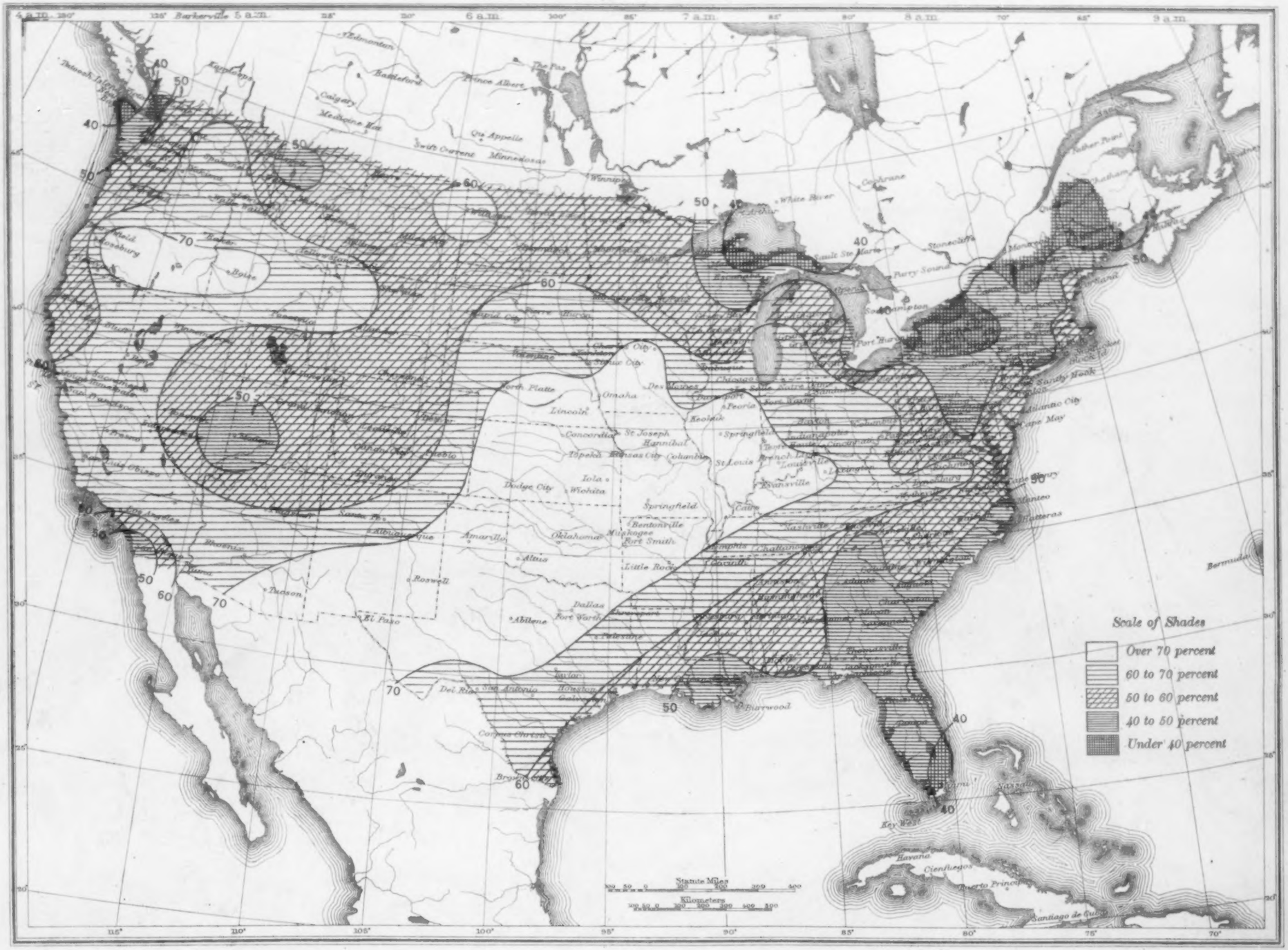


Chart V. Total Precipitation, Inches, September 1939. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, September 1939. (Inset) **Departure of Precipitation from Normal**

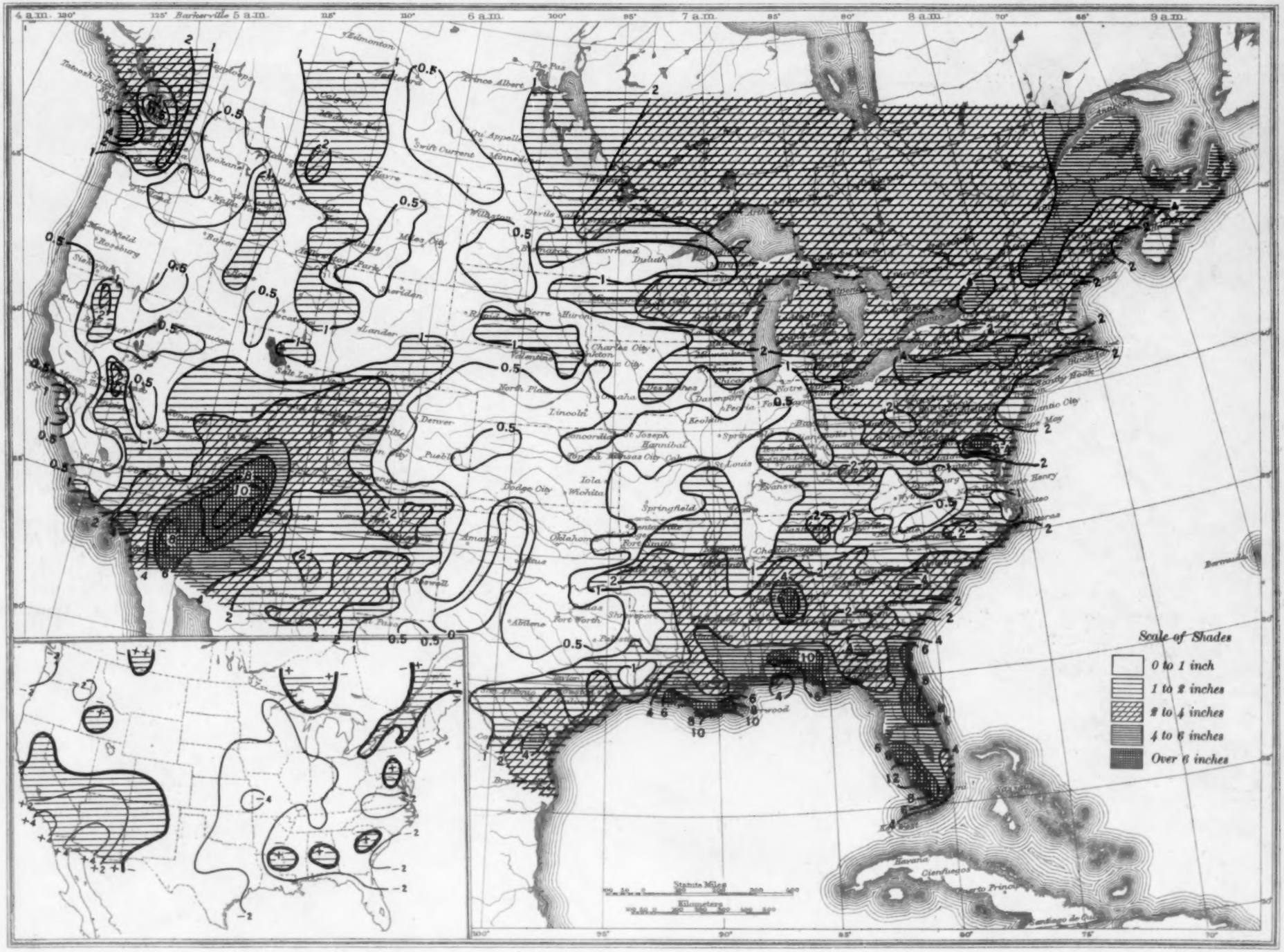


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, September 1939

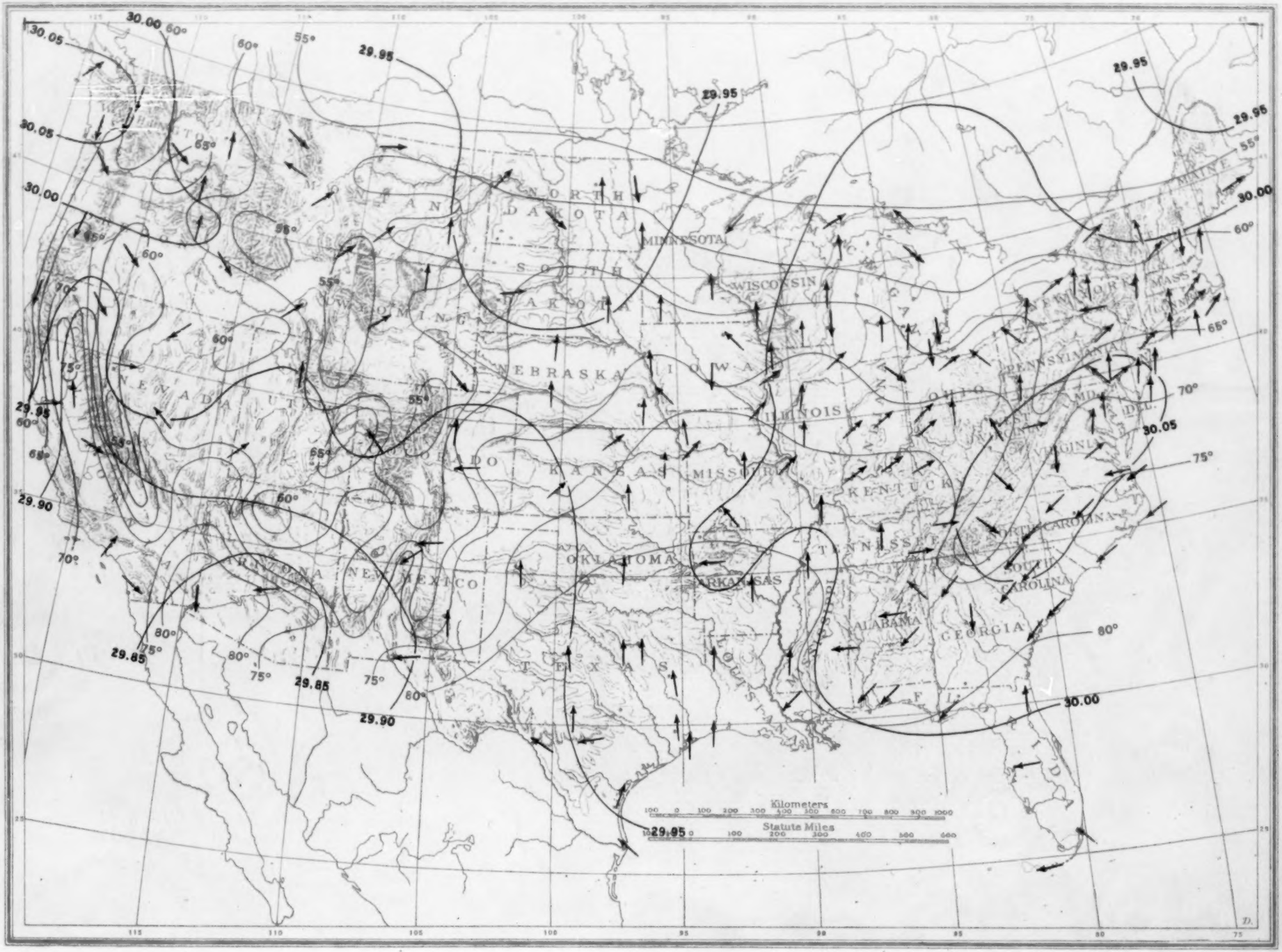


Chart VII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) September 1939

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) September 1939

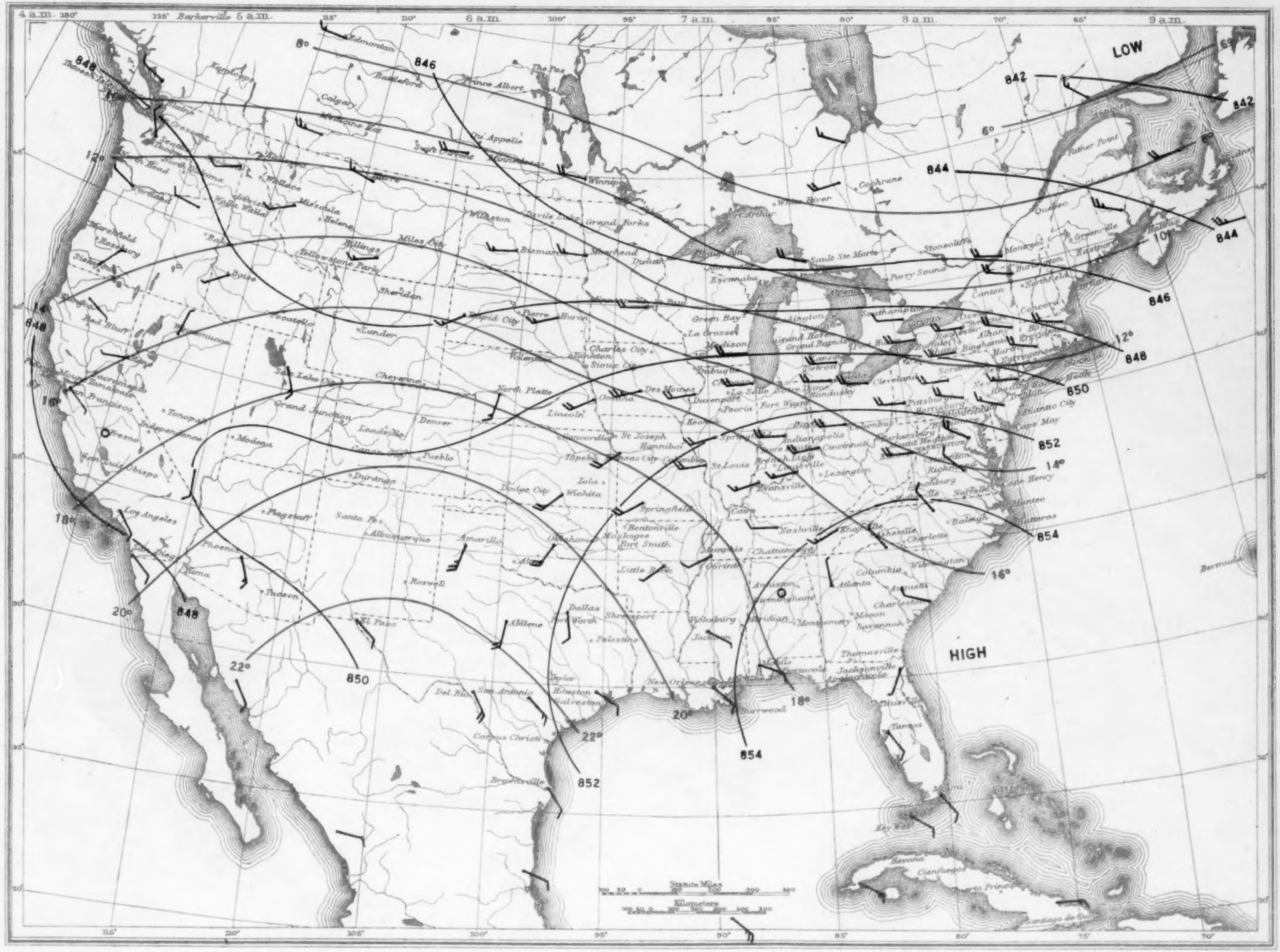


Chart IX. Isobars (mb) Isotherms (°C.) and Resultant Winds for 3,000 Meters (m. s. l.) September 1939

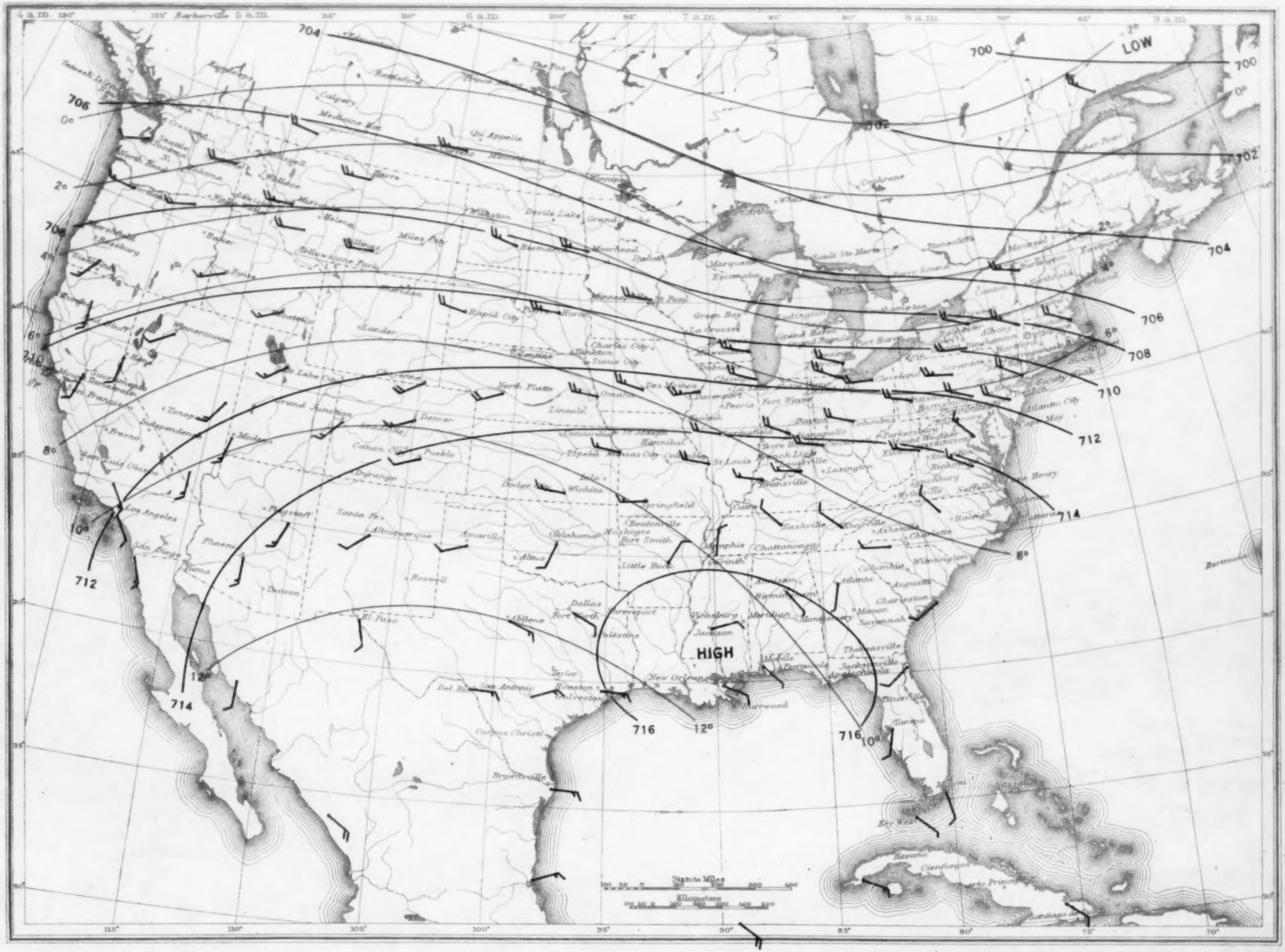


Chart X. Isobars (mb) Isotherms (°C.) and Resultant Winds for 4,000 Meters (m. s. l.) September 1939

Chart X. Isobars (mb) Isotherms (°C.) and Resultant Winds for 4,000 Meters (m. s. l.) September 1939

Chart XI. Isobars (mb) Isotherms (°C.) and Resultant Winds for 5,000 Meters (m. s. l.) September 1939

Chart XII. Mean Isentropic Chart, September 1939 (Potential Temperature 312° A.)

Chart XII. Mean Isentropic Chart, September 1939 (Potential Temperature 312° A.)

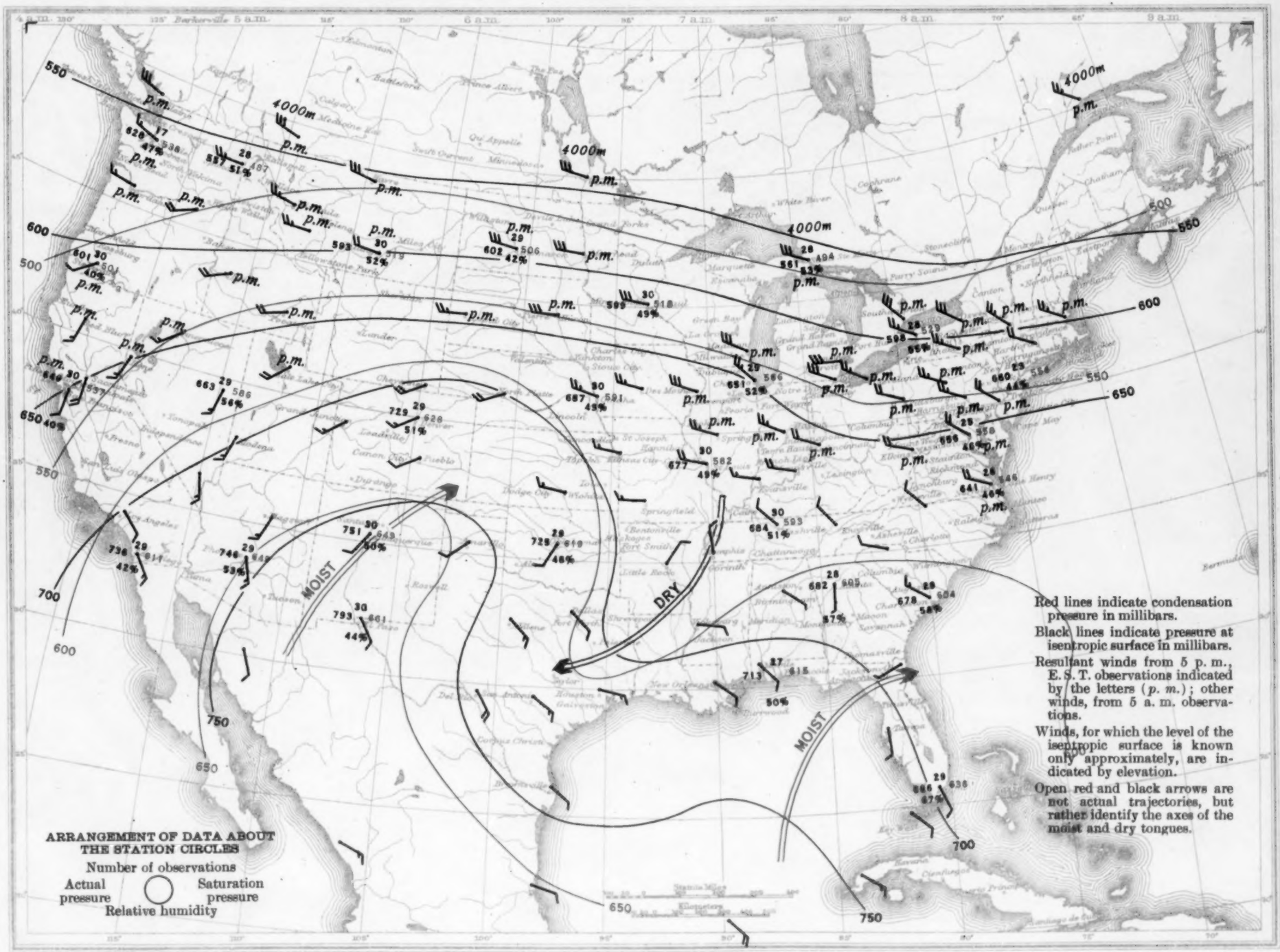
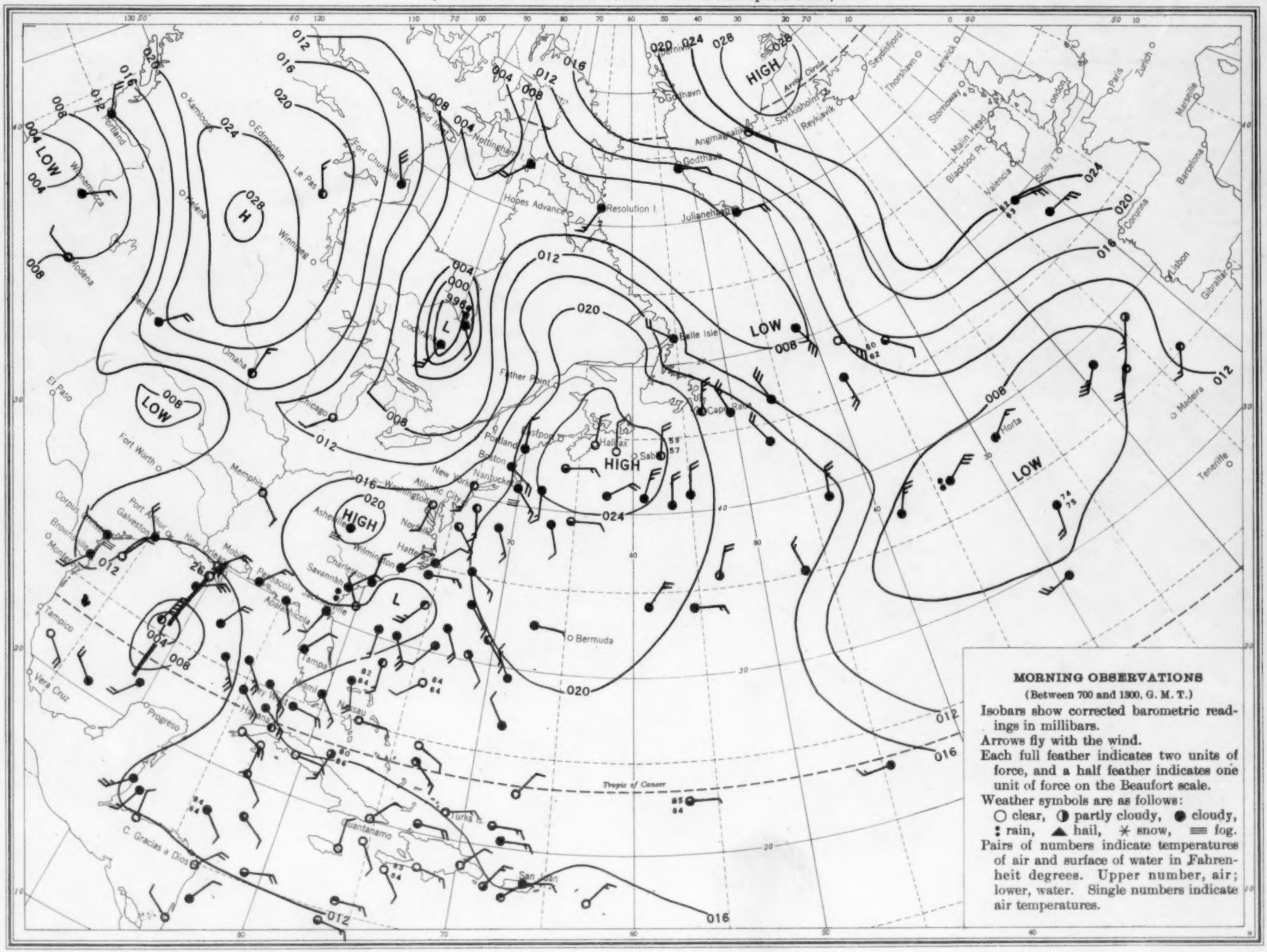

ARRANGEMENT OF DATA ABOUT THE STATION CIRCLES
Number of observations
Actual pressure
Saturation pressure
Relative humidity
MOIST
DRY
MOIST
Red lines indicate condensation pressure in millibars.
Black lines indicate pressure at isentropic surface in millibars.
Resultant winds from 5 p. m., E. S. T. observations indicated by the letters (p. m.); other winds, from 5 a. m. observations.
Winds, for which the level of the isentropic surface is known only approximately, are indicated by elevation.
Open red and black arrows are not actual trajectories, but rather identify the axes of the moist and dry tongues.

Chart XIII. Weather Map of North Atlantic Ocean, September 25, 1929

Chart XIII. Weather Map of North Atlantic Ocean, September 25, 1939

(Plotted from the Weather Bureau Northern Hemisphere Chart)



MORNING OBSERVATIONS

(Between 700 and 1300. G. M. T.)

Isobars show corrected barometric readings in millibars.

Arrows fly with the wind.

Each full feather indicates two units of force, and a half feather indicates one unit of force on the Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail, ✳ snow, ≡ fog.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.

FIGURE 4.—Hailstones at Prytania and Harmony Streets, New Orleans, February 26–27, 1939. (Photo by New Orleans States.)